AD-A119 393 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
FEASIBILITY REPORT FOR FLOOD CONTROL, MINNESOTA RIVER AT CHASKA--ETC(U)
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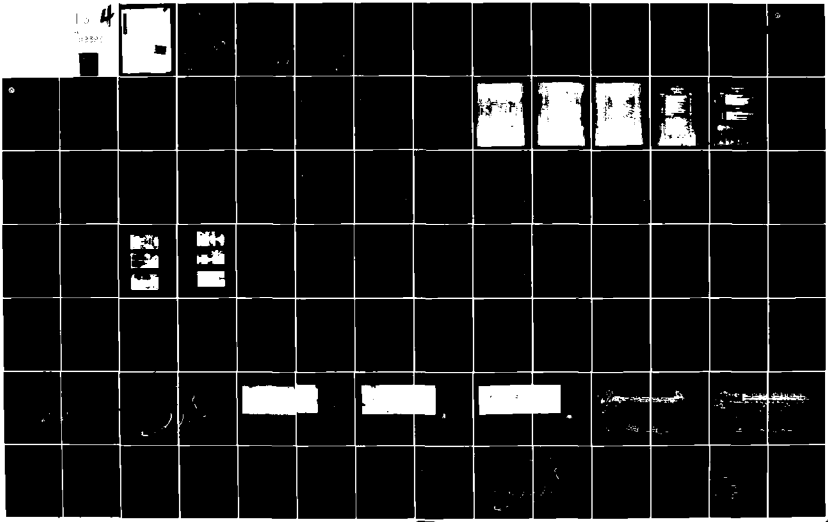

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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3. RECIPIENT'S CATALOG NUMBER	
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	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Paul 1135 USPO & Custom House St. Paul, MN 55101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE August 1973
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16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Flood control
Chaska, Minnesota

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This plan for flood damage reduction and recreation improvements at Chaska consists of a flood bypass channel on East Creek, a diversion channel on Chaska Creek, and levee and interior drainage improvements along the Minnesota River, a recreation trail system, and appropriate floodplain regulation measures. The recreation trails, plantings, and aesthetic treatment of structures should offset adverse effects of the plan, which include relocation of 13 residents.

JOHNSON/37206/jek

DAEN-CWP-A

23 October 1974

The Commissioner
Minnesota Department of Natural
Resources
Centennial Building
St. Paul, Minnesota 55101

Dear Sir:

In accordance with Public Law 78-534 pertaining to coordination procedures on water resources reports and Public Law 85-624 pertaining to fish and wildlife, I am inclosing a copy of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement for your comments.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient, including the views of the agency responsible for fish and wildlife.

A copy of the transmittal letter will be furnished you when the report is transmitted to Congress by the Secretary of the Army.

Sincerely yours,

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

2 Incl
1. Report
2. Environmental Statement

CF: North Central Division wd
St. Paul District wd
Rivers & Harbors Bd wd
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

REGISTERED MAIL - RETURN RECEIPT REQUESTED

JOHNSON/37206/jek

DAEN-CWP-A

23 October 1974

Honorable Wendell R. Anderson
Governor of Minnesota
St. Paul, Minnesota 55101

Dear Governor Anderson:

In accordance with Public Law 78-534 pertaining to coordination procedures on water resources reports and Public Law 85-624 pertaining to fish and wildlife, a copy of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota, is being furnished the Commissioner, Minnesota Department of Natural Resources, as your designated representative, for review and comment, prior to transmission of the report to Congress.

Sincerely yours,

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

CF:
North Central Division wd
~~St. Paul District wd~~
River & Harbor Bd wd
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

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JOHNSON/37206/jek

DAEN-CWP-A 23 October 1974

Honorable Rogers C. B. Morton
Secretary of the Interior
Washington, D. C. 20240

Dear Mr. Secretary:

In accordance with Public Law 85-624 pertaining to fish and wildlife and with established coordination procedures on water resources reports, I am inclosing for your information 17 copies of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient.

Sincerely yours,

2 Incl
1. Report
2. Environmental Statement

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

CF: North Central Division wd
St. Paul District wd
River & Harbor Bd wd
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

DAEN-CWP-A   23 October 1974

Honorable Earl L. Butz
Secretary of Agriculture
Washington, D. C. 20250

Dear Mr. Secretary:

In accordance with established coordination procedures on water resources reports, I am inclosing for your information five copies of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient.

Sincerely yours,

2 Incl
1. Report
2. Environmental Statement

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

CF:
North Central Division wd
St. Paul District wd
River & Harbor Bd wd
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

JOHNSON/37206/jek

DAEN-CWP-A 23 October 1974

Honorable Claude S. Brinegar
Secretary of Transportation
Washington, D. C. 20590

Dear Mr. Secretary:

In accordance with established coordination procedures on water resources reports and your instructions, I am forwarding to the Chief, Ports and Waterways Planning Staff four copies of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient.

Sincerely yours,

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

CF:
Chief, Ports and Waterways Planning Staff
w/2 incl (4 cys)
1. Report
2. Environmental Statement

CF:
North Central Division wd
St. Paul District wd
~~River & [illegible] Bd wd~~
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

JOHNSON/37206/jek

DAEN-CWP-A 23 October 1974

Honorable Caspar W. Weinberger
Secretary of Health, Education,
and Welfare
Washington, D. C. 20201

Dear Mr. Secretary:

In accordance with established coordination procedures on water resources reports, I am inclosing two copies of my proposed report, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient.

Sincerely yours,

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

2 Incl (dupe)
1. Report
2. Environmental Statement

CF: North Central Division wd
St. Paul District wd
River & Harbor Bd wd
Reading File - DAEN-CWA-D

RETURN TO DAEN-CWP-A

JOHNSON/37206/jek

DAEN-CWP-A 23 October 1974

Mr. Francis T. Mayo
Regional Administrator
Environmental Protection Agency
1 North Walker Drive
Chicago, Illinois 60605

Dear Mr. Mayo:

In accordance with established coordination procedures on water resources reports and letter from the Administrator of the Environmental Protection Agency dated 21 October 1971, I am inclosing for your information seven copies of the proposed report of the Chief of Engineers, together with pertinent papers, on Minnesota River at Chaska, Minnesota.

In accordance with Section 102(2)(C) of the National Environmental Policy Act of 1969 (Public Law 91-190), I am inclosing a draft environmental statement.

I would appreciate receiving your comments and recommendations on the report and the draft environmental statement within 90 days, or preferably at such earlier date as may be convenient.

Sincerely yours,

2 Incl (7 cys)
1. Report
2. Environmental Statement

MARVIN W. REES
Colonel, Corps of Engineers
Executive Director of Civil Works

CF:
North Central Division wd
St. Paul District wd
~~River & Harbor Bd wd~~
Reading File - DAEN-CWA-D
Exec OCE, Reading File - DAEN-A-7X

RETURN TO DAEN-CWP-A

JOHNSON/37206/jck

DAEN-CWP-A

23 October 1974

Honorable Walter F. Mondale
United States Senate
Washington, D. C. 20510

Dear Senator Mondale:

There are furnished for your information a copy of the proposed report of the Chief of Engineers and a copy of the report of the Board of Engineers for Rivers and Harbors, on Minnesota River at Chaska, Minnesota.

In accordance with existing law and established coordination procedures, this report is being furnished the Commissioner of the Minnesota Department of Natural Resources, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Transportation, the Secretary of Health, Education, and Welfare, and the Regional Administrator of the Environmental Protection Agency, for review and comment, prior to transmission of the report to Congress.

Sincerely yours,

2 Incl
1. Cy rept COE
2. Cy rept R&H Bd

EARLY J. RUSH III
Colonel, Corps of Engineers
Assistant Director of Civil Works,
Upper Mississippi

SIMILAR LETTERS WERE SENT TO THE FOLLOWING THE SAME DATE:

Honorable Hubert H. Humphrey, US Senate
Honorable Ancher Nelsen, House of Reps.

CF: North Central Division wd
St. Paul District wd
River & Harbor Bd wd
Reading File - DAEN-CWA-D
Exec OCE, Reading File - DAEN-ZX-A

RETURN TO DAEN-CWP-A

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

DAEN-CWP-A

23 October 1974

Mr. Thomas W. Barry
Branch Chief, Natural Resources
Division
Office of Management and Budget
Room 8026, NEOB
Washington, D. C. 20503

Dear Mr. Barry:

There is furnished for the advance information of the Office of Management and Budget a copy of the proposed report of the Chief of Engineers, together with accompanying papers and a copy of the Draft Environmental Statement, on Minnesota River at Chaska, Minnesota.

Appropriate State and Federal representatives have been requested to comment on this report in accordance with the provisions of existing law. When the views of the agencies have been received an additional copy of the report will be furnished the Director, Office of Management and Budget by the Secretary of the Army, together with the proposed letter of transmittal in compliance with Section 4 of Executive Order No. 9384, 4 October 1943.

Sincerely yours,

Marvin W. Rees

MARVIN W. REES
Colonel, Corps of Engineers
Executive Director of Civil Works

3 Incl
1. Report
2. Summary
3. Draft Environmental
Statement

CF: OCF, Mr. Ford w/incl
North Central Division w/5 cys repts COE & R&H Bd wd
St. Paul District w/5 cys repts COE & R&H Bd wd
River & Harbor Bd wd

RETURN TO DAEN-CWP-A

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

DAEN-CWP-A

SUBJECT: Minnesota River at Chaska, Minnesota

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress the report of the Board of Engineers for Rivers and Harbors, accompanied by the reports of the District and Division Engineers, on improvements for flood control and related purposes at Chaska, Minnesota, in partial response to a resolution of the Committee on Public Works of the House of Representatives, United States, adopted 10 May 1962, concerning the advisability of further improvements in the Minnesota River Basin for navigation, flood control, recreation, low flow augmentation, and other related water and land resources. It is also in partial response to an item in Section 6 of the Flood Control Act approved 22 June 1936.

2. The District and Division Engineers recommend construction of a flood control project at Chaska, Minnesota, consisting of a 0.9-mile long diversion channel, a 1.2-mile long flood bypass channel, 1.1 miles of upgraded levee, 0.6 mile of new levee, and appurtenant works. These structural features would be supplemented by a sound local program for controlling flood plain land use and development in remaining flood plain areas in accordance with State law. The total cost of the project is estimated at $9,543,000, of which $8,014,000 is Federal. Total annual charges are estimated at $579,000, including $18,000 for non-Federal maintenance, operation, and replacement. Annual benefits are estimated at $771,000, and the benefit-cost ratio is 1.3.

3. The Board of Engineers for Rivers and Harbors concurs generally in the findings of the reporting officers and recommends construction of the improvements at Chaska subject to certain items of local cooperation.

4. I concur in the views and recommendations of the Board. Use of the currently prescribed interest rate of 5-7/8 percent would not significantly change the benefit-cost ratio.

W. C. GRIBBLE, JR.
Lieutenant General, USA
Chief of Engineers

DEPARTMENT OF THE ARMY
BOARD OF ENGINEERS FOR RIVERS AND HARBORS
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

REPLY TO
ATTENTION OF:

DAEN-BR 9 July 1974

SUBJECT: Minnesota River at Chaska, Minnesota

Chief of Engineers
Department of the Army
Washington, D.C.

1. Authority.--This report is in partial response to the following resolution adopted 10 May 1962:

> Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the report of the Chief of Engineers on the Minnesota River, Minnesota published as House Document 230, 74th Congress, First Session and other pertinent reports, with a view to determining the advisability of further improvements in the Minnesota River Basin for navigation, flood control, recreation, low flow augmentation, and other related water and land resources.

It is also in partial response to an item in Section 6 of the Flood Control Act approved 22 June 1936.

2. Description.--The city of Chaska is in Carver County, Minnesota, on the left bank of the Minnesota River about 20 miles southwest of Minneapolis. Most of the developed portion of the city is subject to flooding from the Minnesota River, and Chaska and East Creeks. At Chaska, the Minnesota River drains about 16,600 square miles of gently undulating prairie. Chaska Creek drains about 15 square miles and flows through the west end of the city, and East Creek drains about 11.8 square miles and flows through the northeast side of the city. Both creeks enter the Minnesota River within the corporate limits of Chaska.

3. Economic development.--The population of the East and Chaska Creek watersheds was approximately 5,250 in 1970, including 4,350 within the city of Chaska. Large tracts of land annexed in 1963 and 1967 brought the city to its present size of approximately 15 square miles which includes Jonathan, the largest planned community in Minnesota. The current Jonathan population of 2,000 is projected

to increase to 50,000 by the year 2000. Although most of the employment for the increased population will be in the Minneapolis-St. Paul metropolitan area, it is estimated that 18,000 new jobs will be created within Jonathan by the year 2000.

4. Existing or authorized improvements. --Federal flood control projects on the Minnesota River have no significant effects on flood stages at Chaska. A levee to protect the city from Minnesota River flooding was constructed by local interests following floods in 1951 and 1952. The Corps of Engineers cooperated with the city in making emergency repairs to the levee after it was breached and overtopped by the 1965 flood. The levee was raised during Operation Foresight prior to the 1969 flood but was not tied into high ground at either end. Following the flood, portions of the emergency works were removed to facilitate interior drainage and normal transportation operations. In 1968, the Jonathan Development Corporation constructed Lake Grace, a 72-acre recreation lake created by a dam in the Upper East Creek watershed. The corporation also has another lake under planning. Although these lakes do not have any designated flood control storage, their combined retarding effect should tend to offset any increases in peak flows due to urbanization of the watershed.

5. Floods and damages. --Flooding in Chaska has occurred frequently from high stages on the Minnesota River. The maximum flood of record occurred in April 1965, and caused tangible flood losses estimated at $2.5 million based on 1973 price levels. Other recent damaging floods at Chaska from the Minnesota River occurred in 1951, 1952, 1957, 1962, 1968, and 1969. The last major flood on Chaska and East Creeks occurred in July 1951. Repetition of such a flood from the creeks could cause extensive damages under present conditions since overflow could pond to depths exceeding 15 feet behind the existing levee system.

6. Improvements desired. --The Chaska City Council has consistently expressed the desire for relief from flood damages. A preliminary plan to divert East and Chaska Creeks, combined with upgrading the existing levee, was supported at a citizen's committee meeting in September 1972, and at public meetings in November 1972 and June 1973.

7. Plan of improvement. --The District Engineer finds that the most practical and economically feasible solution to the flood problem at Chaska includes a 0.9-mile diversion channel on Chaska Creek, a 1.2-mile flood bypass channel on East Creek, 1.1 miles of upgraded levee, 0.6 mile of new levee, and appurtenant works. The project would be designed to provide protection against the intermediate regional flood from the creeks and the Minnesota River. The proposed improvement would require construction of two city street bridges, two county

highway bridges, one United States highway bridge, and three railroad bridges, and modification of one State highway culvert and embankment. In addition, the structural measures would be supplemented by a sound program for controlling flood plain land use and development in remaining flood plain areas in accordance with State law. Proposed recreational development consists of a levee trail system and enhancement of the existing community park at Courthouse Lake in Chaska.

8. Economic evaluation. --Using February 1973 prices, the District Engineer estimates the first cost of the plan of improvement to be $9,543,000, of which $8,014,000 would be Federal and $1,529,000 would be non-Federal. Annual charges, based on an interest rate of 5-5/8 percent and a period of 100 years for economic analysis, are estimated to be $579,000, including $18,000 for non-Federal maintenance, operation, and replacement. Annual benefits are estimated at $771,000, and the benefit-cost ratio is 1.3.

9. Recommendations of reporting officers. --The District Engineer finds that the proposed plan for Chaska is economically feasible, and is consistent with national policy, laws, and administrative directives. He has considered the adverse effects of the proposed improvements, and concludes that the overall public interest will be served by construction of the project. He recommends adoption of the plan, subject to certain conditions of local cooperation. The Division Engineer concurs.

10. Public notice. --The Division Engineer issued a public notice informing interested parties of the recommendations of the reporting officers and affording them an opportunity to present additional information to the Board. No communications were received.

Views and Recommendations of the Board of Engineers for Rivers and Harbors.

11. Views. --The Board of Engineers for Rivers and Harbors concurs in general in the views and recommendations of the reporting officers. The proposed improvements are economically justified, and the requirements of local cooperation are appropriate.

12. The Board has carefully considered the environmental effects of the proposed project, including those discussed in the Draft Environmental Impact Statement dated November 1973, and concludes that although there will be some adverse effects on the environment, the positive effects will far outweigh the adverse impacts.

13. The Board also considered the effects on regional development and social well-being, as required by the Principles and Standards for Planning Water and Related Land Resources recently established by the

Water Resources Council. The Board believes that the proposed improvements will enhance regional development and social well-being through the provision of flood protection and recreational opportunities.

14. The reporting officers find that the existing culvert and embankment on Minnesota Highway 41 over East Creek could be subject to failure during floods which approach the design flow conditions for the proposed Federal channel improvement. They conclude, therefore, that construction of a new bridge over East Creek on Highway 41 is necessary to protect the proposed bypass structure on East Creek from a flood wave that could be generated by a failure and collapse of the existing culvert and highway embankment. The Board notes that the letter assuring local cooperation for the project recognizes the local responsibility to provide the required modification of the existing culvert and embankment.

15. Recommendations.--Accordingly, the Board recommends construction of improvements for flood control and recreation at Chaska, Minnesota, generally in accordance with the plan of the District Engineer, and with such modifications as in the discretion of the Chief of Engineers may be advisable, at an estimated cost to the United States of $8,014,000 for construction: Provided that, prior to construction, non-Federal interests will agree to:

a. Provide without cost to the United States all lands, easements, and rights-of-way, including suitable ponding, borrow, and spoil disposal areas as determined by the Chief of Engineers to be necessary for the construction of the project, at a presently estimated cost of $521,000;

b. Provide the necessary lands for recreation development, subject to the condition that where the appraised value of those lands is less than 50 percent of the total first cost of recreation development, a cash contribution will be made to bring the non-Federal share to at least 50 percent of the total first cost of recreation development, with the non-Federal cash contribution now estimated at $18,000;

c. Hold and save the United States free from damages due to the construction works;

d. Maintain and operate the flood control project and the recreation facilities after completion in accordance with regulations prescribed by the Secretary of the Army, now estimated to cost $18,000 annually;

e. Provide without cost to the United States all alterations and relocations of buildings, utilities, sewers, highway bridges and roads,

including any modification of the Minnesota Highway 41 embankment and culvert at East Creek as may be required by the Chief of Engineers to insure the proper functioning and safety of the Federal improvements on East Creek, and any other special facilities resulting in a local betterment, now estimated to cost $990,000;

f. Prescribe and enforce regulations to prevent obstruction or encroachment on channels and interior ponding areas which would reduce their flood-carrying capacity or hinder maintenance and operation;

g. Publicize flood plain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project; and

h. At least annually inform affected interests regarding the limitation of the protection afforded by the project.

FOR THE BOARD:

/s/D. A. Raymond
D. A. RAYMOND
Major General, USA
Chairman

The Cover

The cover is an aerial photograph of the City of Chaska on 13 April 1965 about one day after the highest flood stage ever recorded at that point on the Minnesota River. The insert pictures depict typical scenes of flooding in the city on 10 April 1965 when the river was still rising.

DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
1210 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

FEASIBILITY REPORT

FOR FLOOD CONTROL

MINNESOTA RIVER

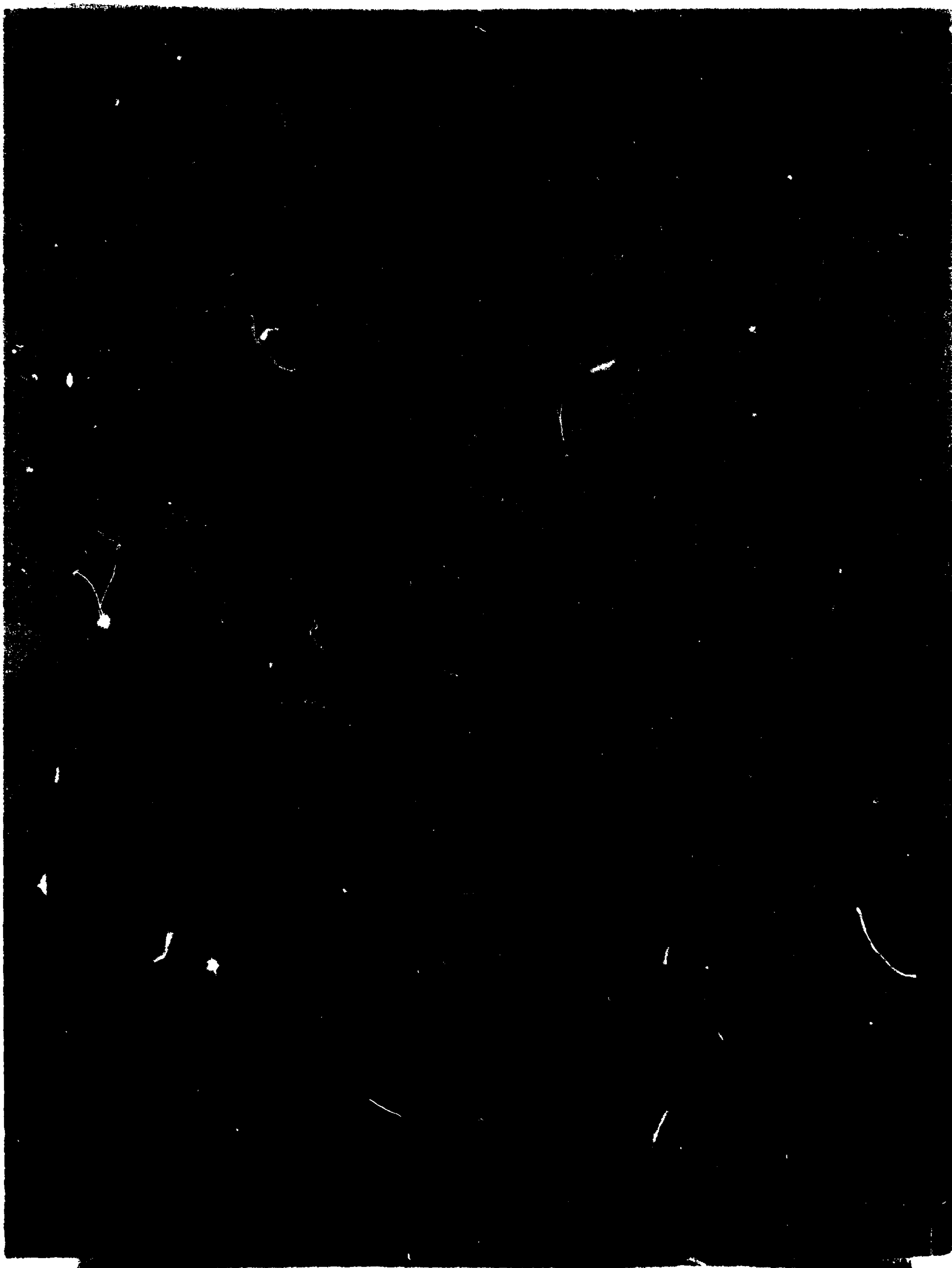
AT CHASKA, MINNESOTA

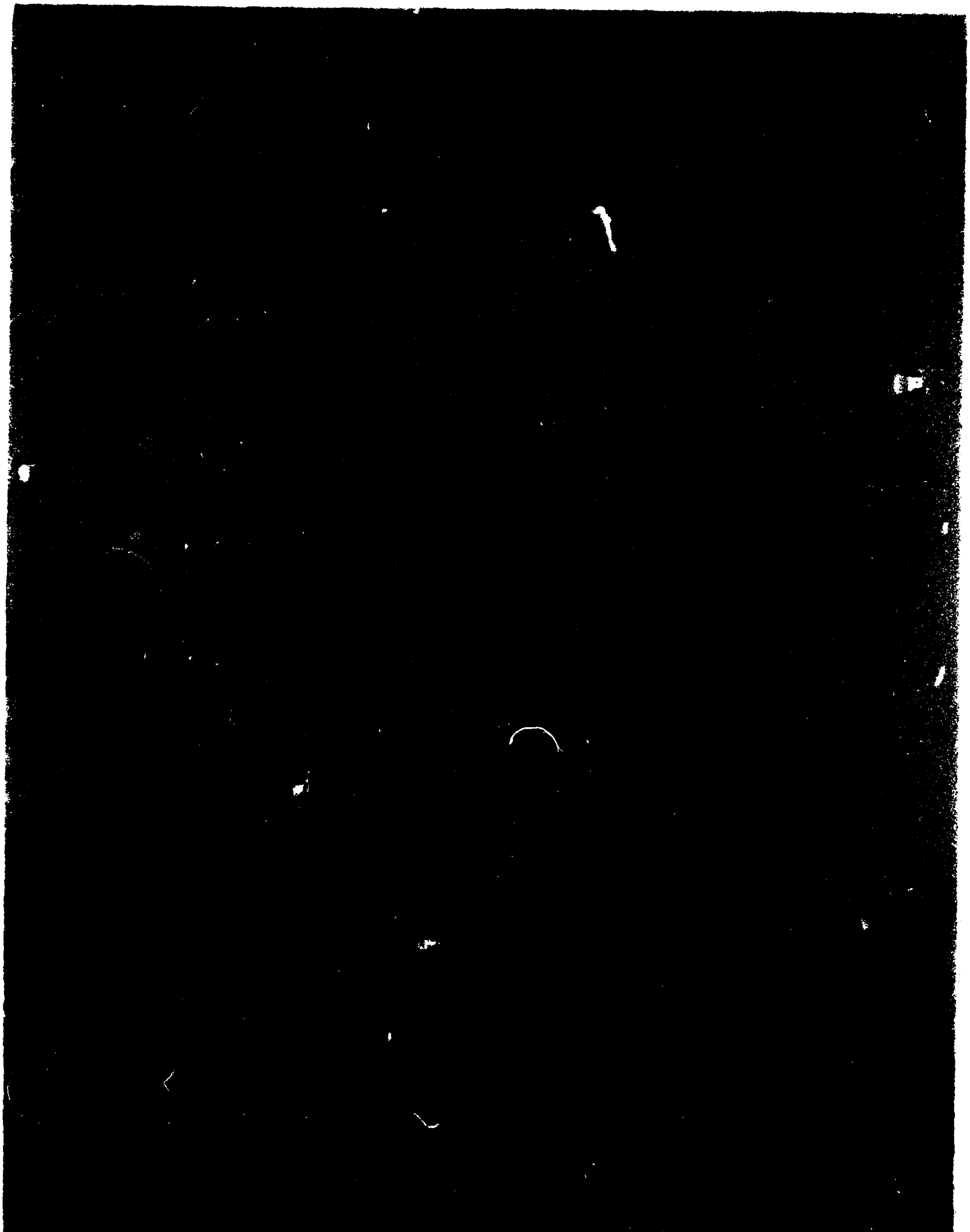
SYLLABUS

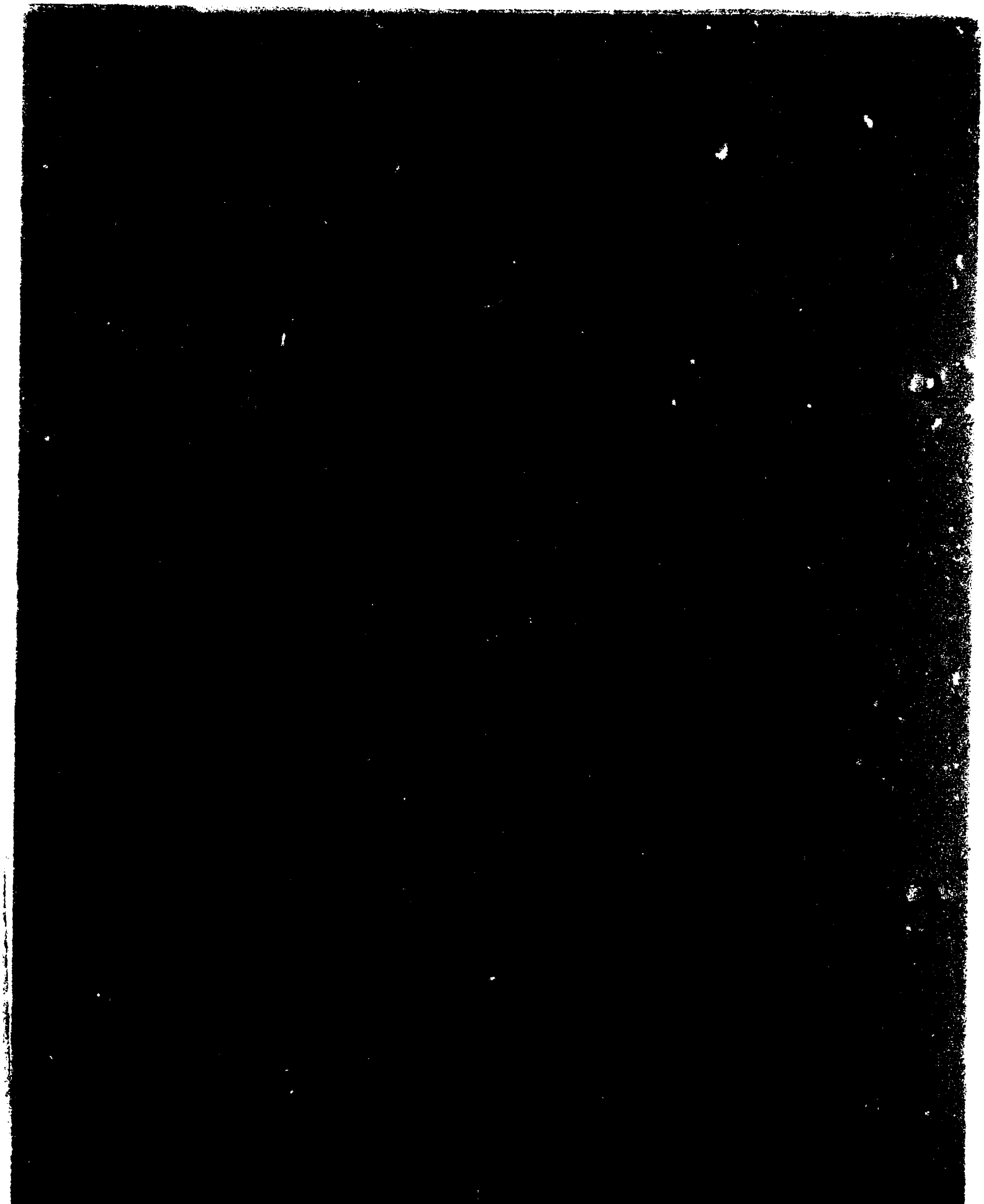
Water resource problems in the Chaska Creek and East Creek watersheds of the Minnesota River basin include the need for reduction of urban flooding, improvement of water quality, and enhancement of recreation and fish and wildlife. The most critical identified need is for reduction in water damages to personal and public property and the avoidance of severe human hardship and suffering, hazard of epidemics, and threat of loss of life resulting from large floods. The floodplain at Chaska consists of approximately 390 acres behind the existing Minnesota River levee and along Chaska and East Creeks. Over 540 residences, 47 businesses and industries, three public buildings, the city water supply and sanitary system, streets, roads, and public utilities are directly affected by flooding of the two creeks and the Minnesota River. Damages estimated at about $4.0 million would result from an intermediate regional flood under present conditions. Of even more significance, this investigation has disclosed that a substantial loss of life could occur at Chaska as a result of either a sudden failure of the existing hastily constructed emergency levee system or potential disastrous consequences of an intense rainstorm in the East Creek or Chaska Creek watershed. The flood potential thus poses a severe threat to the life and security of the residents of Chaska.

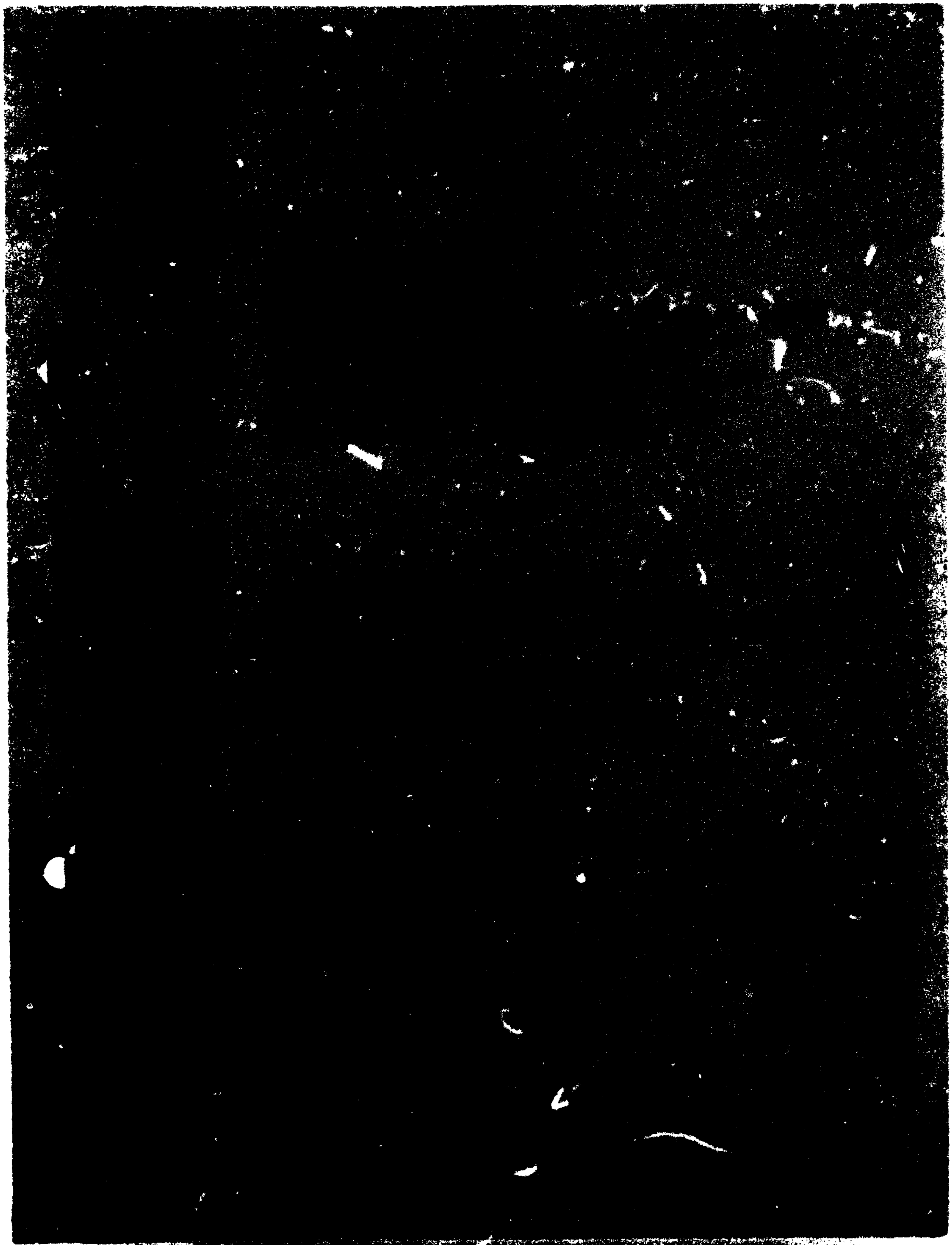
An intensive investigation in cooperation with the city officials, Chaska Citizens Advisory Committee, and State and Federal interests led to development of a floodplain management plan which incorporates both nonstructural and structural measures. The plan as recommended by the District Engineer in this report consists of a 0.9-mile diversion channel, 1.2-mile flood bypass channel, 1.1 miles of upgraded levee, 0.6 mile of new levee and appurtenant works. These structural features would be supplemented by a sound program for controlling floodplain land use and development in remaining floodplain areas in accordance with State law.

The District Engineer recommends that the United States participate in the construction of this flood control project at an estimated Federal first cost of $8,014,000 and non-Federal first cost of $1,529,000, subject to certain conditions of local cooperation. The total estimated average annual cost of the proposed improvements is $579,000 and the average annual benefits would be $771,000, yielding a benefit-cost ratio of 1.3.









DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
1210 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

NCSED-PB

August 1973

SUBJECT: Feasibility Report for Flood Control, Minnesota River at Chaska, Minnesota

Division Engineer
North Central Division
Chicago, Illinois

AUTHORITY

1. This report is submitted in partial response to the following study authorizations:

a. Section 6 of the Flood Control Act of 22 June 1936. -

"The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control at the following-named localities, * * * Minnesota River, Minnesota * * *."

b. A resolution by the Committee on Public Works of the United States House of Representatives, adopted 10 May 1962. -

"Resolved by the Committee on Public Works of the House of Representatives, United States, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the report of the Chief of Engineers on the Minnesota River, Minnesota, published as House Document 230, 74th Congress, First Session and other pertinent reports, with a view to determining the advisability of further improvements in the Minnesota River Basin for navigation, flood control, recreation, low-flow augmentation, and other related water and land resources."

EXTENT OF INVESTIGATION

2. This survey assesses the water resource problems of the East and Chaska Creek watersheds and the Minnesota River at Chaska, Minn. The investigation is based on field instrument surveys; aerial topographic maps; subsurface information; flood damage appraisals;

environmental field investigations; and office analyses of the hydrologic, hydraulic, design, economic, environmental, and social factors involved. Instrument survey data obtained for this study include channel cross sections on East and Chaska Creeks within the Minnesota River valley. Aerial topographic maps prepared for this investigation cover the leveed areas and creek floodplain areas in Chaska. Floodplain information studies included delineation of the floodplain and preparation of water-surface profiles and flood hazard maps for the intermediate regional flood within Chaska. Studies of land use, fish and wildlife conservation, soil conservation, water supply and water quality control, recreation and environmental treatment, and transportation facilities were made in cooperation with other Federal and State agencies.

3. During the course of the studies, local interests were consulted on numerous occasions to obtain their views on possible solutions of flood and other water problems. Details of this coordination are contained in a later paragraph, Coordination with Other Agencies and Interests. Field reconnaissances of the study area were made by the District Engineer and members of his staff including planning, design, soils, and hydraulic engineers; hydrologists; geologists; biologists; and landscape architects.

PRIOR REPORTS

4. Numerous reports on the Minnesota River dating back to about 1867 have been prepared by the Corps of Engineers. The early reports pertained principally to improvement of the river for navigation. The reports made in accordance with the authorization contained in the 1928 Flood Control Act and subsequent acts are concerned primarily with flood control and related water resources.

a. House Document No. 230, 74th Congress, 1st session, which is a survey report dated 6 June 1935, considered the purposes of navigation and development of water power, the control of floods, and the needs of irrigation. This report recommended that further improvement for navigation, power development, flood control, or irrigation not be undertaken at that time.

b. House Document No. 669, 76th Congress, 3d session, contains a survey report dated 27 February 1940 on a general plan of improvement for the Mississippi River between Coon Rapids Dam near Minneapolis, Minn., and the mouth of the Ohio River. This report recommended improvements for navigation and flood control along the Mississippi River and indicated the possibility of providing further flood protection on the Minnesota River.

c. Senate Document No. 144, 84th Congress, 2d session, contains a survey report dated 10 October 1952 for improving navigation and related purposes on the Minnesota River. This report concluded that

the most suitable plan of improvement would be a channel 9 feet deep and 100 feet wide from the mouth to mile 14.2.(1) The River and Harbor Act of 1958, Public Law 85-500, authorized construction of the navigation channel to mile 14.7 in accordance with the Senate Document.

d. House Document No. 437, 84th Congress, 2d session, contains a survey report dated 30 April 1956 for flood control on the Minnesota River at Mankato and North Mankato, Minn. This report recommended raising and strengthening existing levees, constructing two short sections of floodwall, and providing for interior drainage subject to certain conditions of local cooperation.

e. House Document No. 417, 86th Congress, 2d session, contains a report dated 25 March 1960 for flood control on the Redwood River at and in the vicinity of Marshall, Minn. This report recommended channel improvements at Marshall and construction of a levee and a flood diversion channel subject to certain conditions of local cooperation.

f. House Document No. 579, 87th Congress, 2d session, contains a survey report dated 24 June 1960 for flood control on Big Stone Lake-Whetstone River, Minnesota and South Dakota. This report recommended a reservoir and dam on the Minnesota River above U.S. Highway 75 and 3 miles of channel improvements on the Minnesota River downstream from the dam.

g. House Document No. 193, 88th Congress, 2d session, contains a design memorandum for flood control on Big Stone Lake-Whetstone River, Minnesota and South Dakota. This report presents the final design details for the project recommended by the Chief of Engineers in House Document No. 579, 87th Congress, 2d session, and contains supplementing information relating to land acquisition for the national wildlife refuge system.

h. A report, dated 30 January 1970, on Minnesota River, Minnesota, 9-Foot Navigation Channel above Mile 14.7 was submitted to the Board of Engineers for Rivers and Harbors in Washington, D.C., but was returned to the District due to opposition expressed by various local interests. No further work on the study is currently planned.

5. Several preliminary reports on the flood problems at Chaska have been completed. A reconnaissance report dated 8 October 1965 recommended that a detailed project report be prepared to consider flood problems on the Minnesota River at Chaska, as well as potential flooding of Chaska and East Creeks. After initiation of the detailed project study following funding by the Office, Chief of Engineers on 21 December 1965, it became apparent that the cost of providing the desired flood protection would greatly exceed the $1 million Federal cost limitation under the section 205 authority. A letter report was

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(1) Unless otherwise noted, all mileages refer to miles above the mouth of the Minnesota River.

submitted to North Central Division on 5 June 1968 recommending that the study be continued as an interim survey under the authority for study of the Minnesota River basin. By that time the Minnesota River basin study had progressed sufficiently to indicate that reservoirs on the Minnesota River and its major tributaries could significantly reduce Minnesota River flood stages at Chaska. As a result, an interim study of the Blue Earth Reservoir was authorized on 10 December 1968. The Blue Earth Reservoir would, if constructed, provide a high degree of protection at Chaska from Minnesota River flood flows and was considered to be a more desirable alternative than improving the existing local levee. For that reason, Office, Chief of Engineers concluded that preparation of an interim report on the local protection project was not warranted. However, on 28 February 1969, Office, Chief of Engineers requested that studies of improvements to alleviate flood problems at Chaska caused by Chaska and East Creeks be continued under the section 205 authority if a feasible project could be developed.

6. A second reconnaissance report, dated 25 June 1971, indicated that an economically feasible project could be developed to protect the city of Chaska from flooding by Chaska and East Creeks. However, the estimated Federal cost of the project exceeded the $1 million limitation under the section 205 authority. The city of Chaska indicated that it is not capable of paying the costs in excess of the Federal cost limitation. The report recommended that the study be continued as an interim survey under the Minnesota River basin survey authority. The reconnaissance and detailed project report studies indicated that probably the best solution to the potential flood problem on Chaska and East Creeks would be diversion of the flood flows of the two creeks out of the leveed area. Hydrologic studies of the two creeks have been made and preliminary diversion channel designs have been prepared. Surveys of portions of the existing creek channels were made including profiles, cross sections, and bridge sketches. Also, topographic mapping was obtained for one possible diversion route for each creek. Study of a major reservoir system in the Minnesota River basin, which could provide permanent protection from Minnesota River flooding at Chaska, has been suspended until the State of Minnesota can complete a statewide management plan for water and related resources, and until support of the reservoir system by the State is assured. Recent developments indicate that a major reservoir system may not be acceptable to the State of Minnesota and to certain local interests. Thus, current interim survey studies include an assessment of all practical flood damage reduction alternatives to all sources of flooding in the Chaska area.

7. Other reports or studies on the water and related land resources problems in the Chaska area include:

a. Upper Mississippi River Comprehensive Basin Study, prepared under the supervision of the Upper Mississippi River Comprehensive Basin Study Coordinating Committee, June 1972.

b. Field Examination Report of Chaska and Hazeltine-Bavaria Watersheds, by the U.S. Soil Conservation Service, 20 June 1967.

c. Soil Survey, Carver County, Minnesota, by the U.S. Soil Conservation Service and University of Minnesota Agricultural Experimentation Station, 1968.

d. Metropolitan Lake Inventory (Special Publication No. 45), prepared by the Minnesota Department of Natural Resources, Division of Game and Fish, Section of Technical Services, 1967.

e. Memorandum on the Waste Assimilation Capacity of the Lower Thirty Miles of the Minnesota River, prepared by the Minnesota Pollution Control Agency, April 1968.

f. Memorandum on Feasibility of Higher Dissolved Oxygen Standards for the Lower Minnesota River, by the Minnesota Pollution Control Agency, 1971.

g. Corridor Location Study for Trunk Highways 169, 212, and 41, by the Minnesota Department of Highways, 1970.

h. Corridor Resource Analysis for Trunk Highway 212 near Chaska, by the Minnesota Department of Highways, 1972.

i. The Minnesota Outdoor Recreation Plan-1968.

j. The Minnesota Water and Related Land Resources, First Assessment, 1970.

k. Sewerage and Water Planning Report for the Twin Cities Area, by the Metropolitan Council, 1968.

l. A Plan for Recreation Trails in the Minnesota River Valley, by Itasca Engineering, Incorporated, 1969.

m. Jonathan-Design and Development Plan, prepared by the Jonathan Development Corporation, 1971.

n. Report on Water Supply and Distribution System for Chaska, Minnesota, by Bonestroo, Rosene, Anderlik, and Associates, Incorporated, 1971.

o. Report on Comprehensive Sewer Study for Chaska, Minnesota, by Bonestroo, Rosene, Anderlik and Associates, Incorporated, 1972.

p. Comprehensive Plan for Chaska, Minnesota, prepared by Midwest Planning and Research, Incorporated, 1967.

q. Southern Minnesota River Basin Type IV study, which includes the Chaska area, was initiated in July 1973 by the U.S. Department of Agriculture.

r. Minneapolis-St. Paul Metropolitan Area Level B study which includes Carver County was initiated in July 1973 by the Upper Mississippi River Basin Commission.

DESCRIPTION

8. LOCATION AND STREAMS

The city of Chaska is located in Carver County, Minn., on the left bank (north side) of the Minnesota River (mile 29.6) about 20 miles southwest of Minneapolis, Minn. Most of the developed portion of the city is located on the floodplain. At Chaska the Minnesota River drains an area of about 16,600 square miles, as shown on plate 1. Chaska Creek, with a drainage area of about 15 square miles, flows through the west end of the city and an unnamed creek with a drainage area of about 11.8 square miles flows through the northeast side of the city. For this report the latter stream is referred to as East Creek. Both streams generally flow in a southeasterly direction prior to entering the Minnesota River, which flows easterly to its confluence with the Mississippi River.

9. TOPOGRAPHY

The drainage basin of Minnesota River upstream from Chaska consists of gently undulating prairie region at elevations ranging from 700 to 1500 feet above sea level.(1) Floodplain areas at Chaska begin at elevation 705 and average about a mile in width at elevation 730 on the Minnesota River. Much of this area consists of marshes or lakes. The main part of the existing city of Chaska is situated between elevation 710 and 730. An alluvial terrace rises above the older part of Chaska and Minnesota River floodplain to form a prominent bench at about elevation 750. From this terrace the river valley walls rise steeply to form a bluff generally at elevation 850 to 900. Upland areas (elevations 850 to 1070) range from poorly drained marshy areas in the Chaska Creek watershed to rolling hills in the East Creek drainage area. Both creeks flow through deep, steep-walled valleys each about a mile long before emerging on the terraced area of the Minnesota River valley. Two natural lakes, Lake Bavaria, 201 acres, and Hazeltine Lake, 236 acres, lie in the extreme headwaters of the East Creek watershed. Chaska Creek watershed has numerous marsh-type impoundments but no large lakes. Two abandoned clay pits filled by groundwater serve as park areas in the developed part of Chaska.

10. GEOLOGY

The Chaska area has been subjected to glacial action during several periods. The glaciers laid down thick deposits of outwash sands and unsorted tills that today form a hummocky, poorly drained plain dotted with marshes and small lakes. The glacial drift reaches a thickness of 200 to 250 feet and rests on dolomite and sandstone of the Prairie du Chien and Jordan Formations. The large valley of the present Minnesota River was carved by the glacial River Warren, which carried large volumes of water discharging from the now extinct glacial Lake Agassiz, located in western Minnesota and eastern North Dakota. The River Warren, the ancestor to the Minnesota River, cut

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(1) Unless otherwise noted, all elevations in this report refer to feet above msl (mean sea level) datum, 1929 adjustment.

deeply into bedrock and formed prominent terraces. As the flows decreased, the valley was filled to its present level with alluvial sand, silt, and soft clay. The broad floodplain and lower terrace levels are frequently flooded, poorly drained, and characterized by a high water table. Additional information on geology is given in appendix A.

11. STREAM AND SURFACE WATER CHARACTERISTICS

From Big Stone Lake in the headwaters, the Minnesota River descends about 277 feet or an average drop of 0.84 foot per mile, with very little drop downstream from Chaska. East Creek descends about 300 feet in 8 miles for an average slope of 37.5 feet per mile. Similarly, Chaska Creek drops about 300 feet in 10 miles for an average slope of 30 feet per mile.

12. At normal water level the Minnesota River channel averages about 250 feet in width in the Chaska area with a bank-full capacity of approximately 7,000 cfs (cubic feet per second). East Creek varies in width from 30 to 40 feet and at critical sections near U.S. Highway 212 has a bank-full capacity of about 500 cfs. Chaska Creek varies in width from 20 to 40 feet and has a bank-full capacity of about 1,000 cfs.

13. Peak flows of the Minnesota River at Chaska usually occur in the spring as a result of spring snowmelt and occasionally in the summer following intense rainstorms. Normally, days or even weeks of warning would be given prior to the flood crest on the river. During past floods the river has remained above flood stage for 2 to 3 weeks. On East and Chaska Creeks where an intense rainstorm could cause flash flooding within a few hours, little or no warning could be given. Runoff on the creeks would be characterized by high peak flows of short duration.

14. Low flows on the Minnesota River and East and Chaska Creeks occur during the late summer and fall months when evapotranspiration rates are high and also during the winter season when the river and creeks are ice-covered. During times of drought, East and Chaska Creeks could be expected to have little or no flow. The average flow of the Minnesota River at Carver, Minn., which is just upstream from Chaska, is 3,306 cfs or about 0.20 cfs per square mile of drainage area. This average flow is about 42 times greater than the recorded low flow of 79 cfs in 1955. The biological and chemical quality of the Minnesota River at Chaska varies with the seasons but can be described as fair. Relatively high nutrient levels are often present and the river is generally quite turbid.

15. GROUNDWATER CHARACTERISTICS

Abundant quantities of groundwater exist in the Chaska area and all municipal and industrial water supplies are obtained from this source. Chaska presently uses three wells ranging from 125 to 525 feet deep, the deepest of which penetrates sandstone aquifers. A fourth well, presently being drilled, will be 725 feet deep. The existing wells are pumped at a rate of 500 gpm (gallons per minute) and the new well is scheduled to be pumped at a rate of 1,000 gpm. Treatment of the water consists of fluoridation and the removal of iron and manganese by gravity-sand filtration. Wells can also be developed in the Minnesota River valley in terrace gravels and the lower portions of the valley alluvium. Several industries and some private residences presently use this source of water.

16. VEGETATION

The natural vegetation in Chaska Creek and East Creek watersheds originally consisted of a Maple-Basswood subdivision of the Temperate, North American Deciduous Forest. This area included a part of what was known to early settlers as the "Big Woods". Most of the upland areas have been cleared for agricultural purposes and only about 12 percent of East and Chaska Creek watersheds are currently wooded. Dominant tree species in the remaining vestiges of the Maple-Basswood association include sugar maple, basswood, and American elm. Oak associations are common on the drier hills, and along ravines and valley slopes. Typical Floodplain Forests of willow, cottonwood, silver maple, and box elder are prominent in many areas along the Minnesota River floodplain. Also, broad expanses of wetlands are common along the Minnesota River near Chaska. In the watersheds, wetland areas presently constitute about 7 and 13 percent of the East Creek and Chaska Creek drainage areas, respectively, although many of these wetlands have been partially drained. Additional information on vegetation is available in appendix F, Environmental and Aesthetic Considerations.

17. FISH AND WILDLIFE RESOURCES

Significant fish and wildlife values are present in the Minnesota River and its floodplain and the upper watersheds of East and Chaska Creeks. The more immediate study area, however, consists predominantly of urban development. Both East and Chaska Creeks are too small to support a sport fishery and the urban areas of both creeks are essentially channelized. East Creek, for a distance of about 1 mile downstream from the bluffs of the Minnesota River valley, supports a modest aquatic biological system including algae, small invertebrate animals, and a few small fish. The riparian brush and woodlands along this reach of East Creek provide cover for some wildlife including herons which probably feed on small minnows in the stream. Several lakes

which are located in the upper watershed of East Creek, including recently impounded Lake Grace, support significant fisheries and are capable of providing local recreation, fish, and wildlife benefits. The Jonathan Development Corporation, which constructed Lake Grace, is planning for an additional multiple-purpose impoundment immediately upstream from Lake Grace. Aue Lake, located on the Chaska Creek watershed, is capable of supporting a fishery but has no public access. The Minnesota River also supports a significant fishery; however, in the vicinity of Chaska the bottom is mostly shifting sand which provides poor habitat for either fish or aquatic vegetation and animal life. Courthouse Lake, located in a Chaska city park on the Minnesota River floodplain, is managed as a "put and take" trout fishery by the Minnesota Department of Natural Resources.

18. Wildlife cover in the area consists mainly of the Minnesota River floodplain, woodland remaining on the steeper slopes of the upper watershed, and farm woodlots. The local wildlife is concentrated in these areas and is generally absent from the zones of urban development. The wetlands in the upper watershed area are too shallow to provide optimum wildlife habitat. The more prominent and noticeable wildlife species in the study area include pheasant, cottontail rabbit, deer, gray and fox squirrel, ruffed grouse, waterfowl, and muskrat. With increasing urbanization in the upper watersheds, wildlife habitat in the area will likely be reduced in quantity and quality. Environmental quality, however, has been a definite planning objective in the development of the Jonathan unit to date. This is expected to result in preservation or enhancement of some of the more significant natural amenities of the upper watersheds.

19. MINERAL RESOURCES

The principal mineral resources of the Chaska area are the clay deposits which are used for making bricks. These deposits which are found at the base of the Minnesota River valley escarpment and as thick clay lenses within the floodplain at Chaska are nearly exhausted. Sand, gravel, and crushed stone are available from several pits within the watersheds and along the valley walls of the Minnesota River.

20. MAPS

Available maps of the Chaska area include:

a. Topographic quadrangle maps, scale 1:24,000 with 10-foot contour intervals, prepared by the U.S. Geological Survey.

b. Topographic maps, scale 1:250,000, with 50-foot contour intervals, prepared by the U.S. Army Map Service, Corps of Engineers.

c. Topographic maps of portions of Chaska, scale 1:1,200 with 2-foot contour intervals, contracted by the St. Paul District, Corps of Engineers.

d. Topographic maps of flood fringe areas on the Minnesota River, scale 1:6,000 with 2-foot contour intervals, contracted by the U.S. Geological Survey.

e. Topographic maps of Jonathan area, scale 1:2,400, with 4-foot contour intervals, Jonathan Development Corporation.

f. County highway maps, scale 1:126,720, prepared by the Minnesota Department of Highways.

g. River profiles on the Minnesota River, East Creek, and Chaska Creek within the Minnesota River valley and creek cross sections and bridge sketches at Chaska, prepared by the Corps of Engineers.

h. Aerial photographs, scale 1:20,000, prepared by the U.S. Department of Agriculture.

i. Aerial photographs, variable scale, available from private aerial photography firms, 1965-1971.

j. Soil survey maps, scale 1:15,840, prepared by the Soil Conservation Service.

ECONOMIC BASE

21. POPULATION

The total population of the East and Chaska Creek watersheds, including Chaska, was approximately 5,250 in 1970, representing an average density of 140 persons per square mile as compared to 48 persons per square mile for the State of Minnesota. The city of Chaska encompasses 50 percent of the watersheds and had a 1970 census of 4,352. (See table 1.)

Table 1 - Population trends of East and Chaska Creek watersheds, the city of Chaska, and other categories

Item	1950	1960	1970	Percent change 1950-1970
State of Minnesota	2,982,483	3,413,864	3,805,069	27.6
OBE area 06094	1,979,397	2,354,129	2,761,900(1)	39.5
Carver County	18,155	21,358	28,310	55.9
East and Chaska Creek watersheds	2,850	3,850	5,250	84.2
Chaska, Minn.	2,008	2,501	4,352	116.7

(1) Estimated.
SOURCE: 1960 and 1970 census of population, Minnesota, Number of Inhabitants PC(VI)-25; Preliminary Report on Economic Projections for Selected Geographic Areas, 1929 to 2020, Volume I, U.S. Department of Commerce, Office of Business Economics, 1968.

22. The total population of Chaska increased 117 percent from 1950 to 1970. Large tracts of land annexed to the city of Chaska in 1963 and 1967 bring the city to its present size of approximately 15 square miles. Perhaps the most significant annexation was the Jonathan unit which is currently the largest planned community in Minnesota. According to the planning report "Jonathan-New Town: Design and Development," prepared by the Jonathan Development Corporation in 1971, the population of this part of Chaska would be about 50,000 by year 2000. The current population of the Jonathan unit is approximately 2,000 and is growing as expected. Projections by the Chaska city engineer indicate that the total population of Chaska may increase to over 80,000 by the year 2000.

23. EMPLOYMENT AND INDUSTRIES

Employment in the city of Chaska increased from 859 persons in 1960 to 1,723 persons in 1970, an increase of 100 percent. This is compared to an increase of 43 percent for Carver County during the same period. Agricultural employment has been steadily declining in recent years while manufacturing has become the largest employer in the area. In 1970, employment in manufacturing and wholesale and retail trade represented 36 percent and 18 percent, respectively, of total employment for the city of Chaska. The third and fourth largest categories were services and construction, with 15 percent and 9 percent, respectively, as shown in table 2.

Table 2 - Employment by industry sectors, Chaska, 1960-1970

Industry sector	1960 Number	1960 Percent of total	1970 Number	1970 Percent of total
Agriculture, forestry, fishing	20	2.33	-	
Mining	4	0.46	-	
Construction	103	11.99	152	8.82
Manufacturing	236	27.47	617	35.81
Transportation, communication, and other public utilities	37	4.31	85	4.93
Wholesale and retail trade	236	27.47	316	18.34
Finance, insurance, and real estate	20	2.33	103	5.98
Services	123	14.32	250	14.51
Public administration	39	4.54	59	3.43
Industry not reported	41	4.78	141	8.18

24. The most significant growth in employment for Chaska is expected to occur within the Jonathan unit. The Jonathan Development Corporation estimates that 18,000 new jobs will be created by year 2000. Development in the Jonathan Industrial Park adjacent to Hazeltine Lake is currently progressing ahead of schedule. Although employment in the remainder of Chaska will increase as the population expands, many residents will continue to be employed in the Twin Cities metropolitan area.

25. TRANSPORTATION

The principal highway and railroad routes in the Chaska area are shown on plate 1. The Minnesota Department of Highways has conducted a planning study for the relocation of State Highway 41 and U.S. Highway 212, which indicated that the best overall alignments are those shown on the map. A 9-foot navigation channel with a 100-foot bottom width to mile 14.7 at Savage, Minn., on the Minnesota River is currently maintained by the Corps of Engineers. Air transportation is provided through the general aviation airport at Flying Cloud Field in nearby Eden Prairie, Minn., with commercial flights available from Minneapolis-St. Paul International Airport about 20 miles east of Chaska.

26. TRENDS OF GROWTH AND DEVELOPMENT

Growth and development in the Chaska area are expected to increase rapidly in the next few years. Rates of growth should far exceed the national average due to the development of the planned community of Jonathan (estimated population 50,000 by year 2000) in the northern part of the city, and the reconstruction of Minnesota Highway 41 and U.S. Highway 212. The population of Chaska is expected to increase from 4,352 in 1970 to about 80,000 in the year 2000, or an increase of approximately 18 times the present population. The East Creek watershed would be fully urbanized and Chaska Creek watershed would be nearly 50 percent developed. Floodplain zones in the upland areas of the watersheds would be generally preserved as greenways but development in the floodplain of East Creek within the Minnesota River valley could be substantial. Flood hazard areas downstream from the bluff on East Creek and Chaska Creek would be subject to the city floodplain zoning ordinance since much of the required engineering hydraulic information for floodplain zoning is contained in this report. Nevertheless, development pressures will likely be heavy along East Creek upstream from U.S. Highway 212 since the alternative would be to develop highly valued land above the bluff zone. Little new development is expected within the leveed area of Chaska since these areas are already nearly fully developed.

CLIMATOLOGY

27. Climatological records, published by the National Weather Service, have been available since 1925 for the Chaska weather station. The mean annual temperature for Chaska is about 45° F, with the mean monthly temperature varying from about 74° F in July to 14° F in January. The most extreme temperatures have been recorded as a high of 109° F in July 1936 and a low of -43° F in January 1951. Chaska has an average frost-free season of about 153 days. The average annual precipitation in Chaska is about 27 inches with extreme annual variation of 16 to 40 inches. Average monthly precipitation varies from a maximum of 4.88 inches in June to a minimum of 0.54 inch in January. The maximum rainfall amount recorded at Chaska for a 24-hour period is 4.96 inches, occurring on 8 July 1955. Snowfall records for Minneapolis, which is located approximately 20 miles northeast of Chaska, indicate an average annual snowfall of about 44 inches. The snowfall represents approximately 16 percent of the yearly precipitation.

RUNOFF AND STREAMFLOW DATA

28. STREAMFLOW RECORDS

Streamflow data have been obtained by the U.S. Geological Survey on the Minnesota River just upstream from Carver from 1934 to date. A staff gage is used at Chaska to record flood levels on the Minnesota River since high-water levels on the Mississippi River 29.6 miles downstream affect flood stages at Chaska. No streamflow records are available on either Chaska or East Creeks, although several older residents of Chaska have indicated that large floods have occurred in the past, most notably in July 1951.

29. RUNOFF CHARACTERISTICS

The Minnesota River generally attains its highest discharge of the year in March or April from runoff caused by snowmelt or a combination of snowmelt and rainfall. The months of May through September generally have high flows consistent with the monthly precipitation pattern. Flood stages usually rise relatively slowly on the Minnesota River but, once reached, can last for 2 to 3 weeks before receding.

30. Runoff from East and Chaska Creeks is of the flash flood type characterized by high peak flows of short duration. The crests on the creeks could be expected within a few hours after heavy rains occurred over the watersheds. Normally runoff from a regional rainfall or snowmelt event would have exited East and Chaska Creek watersheds long before peak flows occurred on the Minnesota River at Chaska. However, the chance of having an intense local rainstorm at Chaska during a flood on the Minnesota River will always exist. Such a combination of events could produce catastrophic flood losses.

31. Planned urbanization of the East Creek watershed would greatly increase runoff. However, existing Lake Grace Dam and proposed Upper Lake Grace dam would have a significant retarding effect on flood flows by reducing future peak flows to approximately present undeveloped conditions. In the Chaska Creek watershed, where land-use plans indicate that approximately 50 percent of the watershed will eventually become urbanized, peak flood flows would increase about 25 percent over present conditions.

32. Low flows in the Minnesota River basin occur during the late summer and fall months when evapotranspiration rates are high and during the midwinter months when the streams are ice-covered. The minimum flow recorded on the Minnesota River at Carver was 79 cfs and occurred 17 November 1955. During such extended dry periods, East and Chaska Creeks could be expected to cease flowing.

FLOODS

33. GENERAL

Flooding in Chaska has occurred frequently from high stages on the Minnesota River. The greatest flood of record occurred in April 1965 when a peak stage of 722.25 was reached. The 1969 flood reached a peak stage of 720.4. In 1952 a flood having a peak stage of 717.10 caused extensive damage. Other damaging floods occurred during the years 1881, 1919, 1936, 1943, 1944, 1947, 1949, 1951, 1957, 1962, and 1968. The largest of these floods is generally associated with spring snowmelt conditions.

34. Floods have also occurred on Chaska and East Creeks, although documentation of such floods is limited to newspaper accounts and interviews with older residents of the community. The last major flood on the creeks occurred in July 1951. Repetition of such a flood would cause much more damage now since overflow from either or both of the creeks could pond to depths exceeding 15 feet behind the existing levee. Also, recent residential and commercial developments have been encroaching into the overflow area of East Creek in a terrace along the Minnesota River floodplain upstream from the leveed area. High flows on East Creek could cause extensive damage in this terrace area. Anticipated future industrial and residential improvements in the Jonathan development located in the headwaters of East Creek are expected to increase runoff substantially, although existing and planned retarding reservoirs will nearly cancel any increase in peak flows at the East Creek terrace area. Generally, intense local rainstorms would cause the most severe flooding conditions on East and Chaska Creeks, although snowmelt combined with rainfall could also cause major flooding.

35. LOSS OF LIFE POTENTIAL

There have been no reports of loss of life associated with flooding at Chaska in the past. However, two potentially hazardous conditions exist in Chaska which could result in substantial loss of life. First, the existing emergency levee along the Minnesota River was hastily constructed and does not have adequate seepage control. At high river stages, seepage flows could undermine the levee and cause it to collapse. In a matter of minutes the protected area could be flooded to depths exceeding 15 feet. The second hazardous area is on East Creek where the stream emerges from along the bluff of the Minnesota River. Part of Minnesota Highway 41 is a 30-foot-deep fill crossing East Creek about 1 mile upstream from the bluff and has the potential to hold back a relatively large volume of floodwater because of the small-size culvert under the road. If the water level rose to the top of the road, which could happen during an intense rainstorm, and the road embankment were to collapse, a flood wave several feet deep could travel down the narrow valley and enter a mobile home park and a residential area of Chaska within minutes. The impactive forces of such a wave could have catastrophic consequences.

36. FLOOD FREQUENCIES

Annual instantaneous peak discharge-frequency relationships for the Minnesota River at Carver were derived statistically from existing gage records at Carver and Mankato. The short-period records at Carver were statistically adjusted and correlated to the longer period records at Mankato which were correlated with records on the Mississippi River at St. Paul.

37. Stages on the Minnesota River below Carver to the mouth at Mendota, Minn., are affected by high stages of the Mississippi River at Mendota. Consequently, river stages and flood damages in this reach cannot be related directly to discharges. Instead, an elevation-frequency curve was developed at Chaska using the Carver gage on the Minnesota River and an elevation-frequency curve at the mouth of the Minnesota River from discharges at the St. Paul gage on the Mississippi River. Table 3 summarizes peak flood elevations to be expected at selected frequencies at the staff gage in Chaska. The U.S. Geological Survey, in cooperation with the Minnesota Department of Natural Resources, is currently conducting detailed hydraulic studies of the lower Minnesota River for floodplain information purposes. Results of these studies will be incorporated into postauthorization planning and design.

Table 3 - Flood frequency data for the Minnesota River at Chaska, Minn.

Frequency (in percent)	Peak elevation (feet)	Remarks
1	723.0	Intermediate regional flood.
	722.25	1965 flood.
2	721.0	
	720.4	1969 flood.
4	718.8	
5	718.0	
10	715.6	

38. In the absence of recorded flood discharges on Chaska and East Creeks, frequency curves were developed synthetically for urbanized hydrologic conditions. The East Creek curve reflects the flood-retarding effect of Lake Grace Dam and Reservoir in Jonathan. Similarly, the retarding effect of the marshes in the Chaska Creek watershed have been recognized. (See table 4.)

Table 4 - Flood frequency data for East Creek where it exits the bluff of the Minnesota River valley and Chaska Creek at the First Street Bridge at Chaska, Minn.

Frequency (in percent)	East Creek peak flow (cfs)	Chaska Creek peak flow (cfs)
1	4,350	4,700
2	3,500	3,880
4	2,720	3,150
5	2,500	2,950
10	1,880	2,330

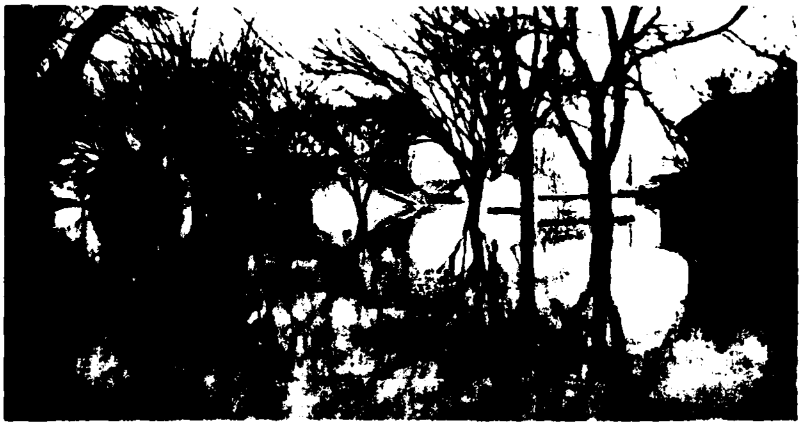
39. STANDARD PROJECT FLOOD

The standard project flood is defined as the flood that might be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably characteristic of the geographical region involved, excluding extremely rare combinations. The standard project flood from the Minnesota River at Chaska has an estimated peak discharge of 168,000 cfs, which is approximately 1.4 times the record flood of 1965. The estimated peak discharge of the standard project flood at Chaska from Chaska Creek and East Creek is 16,500 cfs and 8,430 cfs, respectively. Details on the derivation of the standard project floods are given in appendix B.

FLOOD DAMAGE

40. EXTENT AND CHARACTER OF FLOODPLAIN

The floodplain at Chaska consists of approximately 570 acres outside the Minnesota River levee and approximately 390 acres behind the levee and along East and Chaska Creeks. Approximately 100 acres of this floodplain adjacent to the Minnesota River are subject to flooding from the river or the creeks, 230 acres are subject to flooding from East Creek only, and 60 acres from Chaska Creek only. About 34 percent of the floodplain inside the levee is used for residential purposes, 18 percent is occupied by commercial property, 7 percent is utilized for streets and railroads, and 4 percent is public property. Vacant land accounts for the remaining 37 percent of the total land. Although this vacant land is quite low and probably could be considered more suitable for recreational use, continued development in this area is occurring. The floodplain within the city of Chaska presently contains 540 dwelling units, 46 commercial units, one industrial complex, and three public buildings. The 570 acres riverward of the levee consist mainly of marshland. The intermediate regional floodplain area at Chaska under expected future runoff conditions is shown on plate 2. Flood conditions at Chaska are illustrated by photographs Nos. 1 through 6.



Photograph No. 1 - Looking south from near the corner of Elm and First Streets, 10 April 1965.

Photograph No. 2 - Looking south along Cedar Street toward city levee being overtopped by floodwaters from the Minnesota River, 10 April 1965.

Photograph No. 3 - Local emergency operations to protect the Carver County Courthouse at Chaska, 11 April 1965.

Photograph No. 4 - Looking south from near the intersection of Pine and First Streets, 12 April 1965.

Photograph No. 5 - Looking west from the intersection of Hickory and First Streets, 12 April 1965.

Photograph No. 6 - Aerial view looking northeast and downstream at Minnesota Highway 41 bridge over the Minnesota River at Chaska, 13 April 1969.

41. FLOOD DAMAGE SURVEYS

Information on flood damages at Chaska was obtained from field surveys and interviews conducted in 1967 and 1972. Residential damage surveys were then correlated with property values and depths of flooding. Estimates of flood damages to commercial and public properties were obtained through personal interviews. All flood damage evaluations are based on February 1973 price levels. At these price levels the record 1965 flood would have caused $2.3 million in tangible flood losses.

42. NATURE OF FLOOD DAMAGES

Nearly all the flood damages in the Chaska and East Creek watersheds occur in Chaska near the Minnesota River or on the East Creek terrace within the Minnesota River valley. The flood problems at Chaska are aggravated by the fact that both East and Chaska Creeks pass through the populated areas. Overflows from the creeks could pond behind an existing levee and cause extensive damage. Furthermore, recent developments along East Creek just upstream from the central business district could be severely flooded by runoff from intense rainfall over the watershed. Table 5 presents a breakdown of the total flood damages into various urban land-use types at Chaska for the intermediate regional flood.

Table 5 - Summary of urban flooding at Chaska

Type	Percentage of total urban damages for intermediate regional flood
Residential	78
Commercial and industrial	11
Public and other	11
Total	100

43. Flood losses at Chaska can be especially severe because of the flash flood nature of the two creeks and also because of the dense urban development within the floodplain. Flash flooding would cause higher than normal damages since few personal belongings could be saved in the rush to evacuate the area. Also, the existing levee which provides partial protection from the Minnesota River could be outflanked by a flood having about a 3-percent chance of occurring in any given year. Damages resulting from levee overtopping could be equally severe.

44. EVALUATION OF FLOOD DAMAGES

The evaluation of the flood damage potential at Chaska was correlated with flood frequency data of the Minnesota River and East and Chaska Creeks to obtain average annual damages. The flood frequency data were adjusted to assure no duplication of damages would be included due to coincidental flooding from the Minnesota River and the two creeks. In the analysis, present condition flood damages are based on the damage potential expected in 1980, the earliest date that any improvement would likely be completed. Thus, the estimated average annual damages based on 1980 conditions and anticipated conditions 100 years hence in 2080 would be $806,000. Further details of the evaluation of flood damages and the development of average annual damages are provided in appendix C.

EXISTING AND AUTHORIZED WATER RESOURCE PROJECTS

45. CORPS OF ENGINEERS

The Lac qui Parle Lake near the head of the Minnesota River has no significant effect on flood stages at Chaska. No other Federal flood control projects have been constructed in the vicinity of Chaska. The Corps of Engineers presently maintains a 9-foot navigation channel from the mouth of the Minnesota River to mile 14.7 at Savage, Minn. Presently there are no plans to construct an extension of the commercial navigation channel.

46. IMPROVEMENTS BY OTHER AGENCIES

Following the floods in 1951 and 1952, local interests constructed a levee with 3 feet of freeboard to protect Chaska against a flood having a 5-percent chance of occurring in any 1 year on the Minnesota River. As a result of the severe 1965 flood, the Corps of Engineers cooperated with the city of Chaska in making emergency repairs of the levee which had been breached. The city of Chaska subsequently raised the levee about 4 feet at local expense. The levee was again raised about 2 feet, under Operation Foresight, prior to the 1969 flood. Following the flood, portions of the levee were removed and the levee was not tied into high ground at either end.

47. In 1968 the Jonathan Development Corporation constructed a 25-foot-high earth fill dam on East Creek about 4.8 miles upstream from the Minnesota River. Lake Grace, the 72-acre lake created by the dam, is currently used for recreation and aesthetic purposes. It was designed to pass a 1-percent chance flood and has no designated flood control storage. The Jonathan Development Corporation is currently planning to construct a second 25-foot-high earth dam immediately upstream from the Milwaukee Road railroad embankment which is about 1 mile upstream from the existing Lake Grace Dam. Although this reservoir would also not have any designated flood control storage, the combined retarding effect of the two reservoirs would approximately offset any increases in peak flows due to planned urbanization.

48. The Carver County Soil and Water Conservation District has been active in working with farmers to develop a good land treatment program. The District expects to work closely reviewing site plans for urban uses in the future, in the Chaska and East Creek watersheds.

49. FLOOD EMERGENCY OPERATIONS

In an effort to save the city from a repetition of the devastating flood damages which occurred in 1952 and 1965 at Chaska, the community waged a successful but costly flood fight in 1969. During this flood, the city of Chaska was assisted by the Corps of Engineers, Red Cross, Civil Defense, Carver County, and hundreds of volunteer workers. The flood fight involved raising the existing 8,000-foot-long levee about 2 feet and constructing about 2,000 feet of temporary dikes. As the flood crest approached (elevation 720.4), the high water pressures caused considerable seepage but 17 portable pumps ranging in size from 3- to 10-inch capacity were able to cope with the seepage problems. The total cost to raise and extend the existing emergency levee system and provide portable pumps exceeded $217,000, including the contract work done by the Corps of Engineers under authority of Public Law 99. Damages prevented by the 1969 flood fight exceeded $650,000. However, approximately $440,000 in damages were sustained, principally as a result of highway traffic interruption across the Minnesota River at Chaska.

WATER AND RELATED LAND RESOURCE NEEDS

50. FLOOD CONTROL

Periodic flooding of the urban areas of Chaska is currently the most serious water resource problem in the East and Chaska Creek watersheds and along the Minnesota River at Chaska. Over 500 residences, 47 businesses and industries, and three public buildings would be directly affected by flooding of the two creeks and the Minnesota River. Damages estimated at $4 million would result from an intermediate regional flood (1-percent chance flood) under present conditions. Also, severe disruption of the community and possible loss of life could result.

51. WATER SUPPLY

In general the Chaska area has a plentiful supply of good quality groundwater and all foreseeable water supply demands can be satisifed using groundwater. These projected demands recognize the needs of over 80,000 people and anticipated industrial growth in the city.

52. WATER QUALITY

The water quality of East and Chaska Creeks is generally good. However, the Minnesota River at Chaska is a slow-moving, silt-laden river and, during times of low river flow, can have an oxygen-depletion problem. This problem is primarily due to the limited assimilative capacity of the Minnesota River for point sources of treated waste water. Also, agricultural processing plant wastes and inadequate safeguards during the application of agricultural pesticides and fertilizers have led to periodic degradation of stream quality upstream from Chaska.

53. RECREATION, FISH AND WILDLIFE

The Chaska area has been endowed with a plentiful supply of lakes and marshes which satisfy a large portion of the demand for water-related recreation activities. However, a greater interest in the environment has also led to an increased demand for parks, trails, and general outdoor recreation areas. To meet these demands, at least in part, recreation facilities and environmental interpretive areas should be further developed in Chaska.

54. Similarly, preservation and enhancement of fish and wildlife habitat within the watersheds are needed. As the area becomes urbanized, protective measures to reduce erosion and runoff should be included as an integral part of development. Preservation of marshes, creek bottoms, and wooded ravines would provide wildlife habitat and nature study areas while maintaining a natural waterway for safe passage of flood flows.

IMPROVEMENTS DESIRED

55. Solutions to the urban flood problems in Chaska have been requested by the city of Chaska. In April 1965 the city council adopted a resolution requesting the Corps of Engineers to study the flood problems under section 205 of the 1948 Flood Control Act, as amended, which allows Federal participation of up to $1 million for economically justified and environmentally and socially acceptable projects. This preliminary report indicated that the diversion of East and Chaska Creeks combined with upgrading the existing levee could provide an adequate degree of protection for the community. However, the cost of such measures would have far exceeded the Federal cost limitations. With the city unable to provide the additional required funds, the Office, Chief of Engineers approved the District's request to prepare an interim survey report.

56. Subsequent to this approval, several meetings with local officials were held to discuss desired improvements. At a meeting on 13 September 1972, the Chaska Citizens Advisory Committee expressed continued support for the creek diversion concept combined with a plan for upgrading the existing levee. Support for creek diversions and levee improvements was again expressed at a public meeting on 21 November 1972. During this meeting, 14 alternative methods for managing floodplain areas in Chaska were reviewed. Local interests indicated that the alternative of permanent floodplain evacuation would not be acceptable due to the large number of residences needing relocation. Also, they stated that community cohesion would be destroyed and that an uneconomic community unit would remain following evacuation. Concern was expressed that the entire community below the bluff of the Minnesota River valley would eventually be lost. At a meeting of the Chaska Citizens Advisory Committee on 21 March 1973, the proposed creek diversion and levee improvement plan was presented. The committee generally agreed with the proposed plan and indicated a strong preference for a levee extension route passing to the east of Courthouse Lake (see plate 3). The committee stated that safety, aesthetics, recreation, and quality of life would all be improved with such a levee alignment.

PLAN FORMULATION

57. OBJECTIVES

The basic objectives of plan formulation are to develop a plan which will provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs of the Chaska area. In pursuit of this general objective, the following specific planning principles and objectives guided formulation of the plan of improvement.

a. The plan must preserve to the maximum possible extent the quality of the natural and human environment.

b. The plan must be socially acceptable.

c. The plan must enhance the economic welfare of the local people and add to their security and well-being.

d. The plan must enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.

e. The plan must fit integrally into an overall plan for water and related land resource management and development for the Upper Mississippi River basin.

f. The plan must be technically feasible to implement.

58. CONSIDERATION OF THE WATERSHED NEEDS

There is an existing or pending need for water quality control, recreation, fish and wildlife enhancement, and flood control in or downstream from the East and Chaska Creek watersheds. Glacial till and other deeper aquifers provide a good source of groundwater which should meet the foreseeable water supply needs of the Chaska area. The only significant water quality problem anticipated in the area is on the Minnesota River downstream from the existing waste-water treatment plant where oxygen depletion could occur during times of low streamflow. Advanced waste treatment, low-flow augmentation, or on-land disposal of waste water are methods which might prove effective in coping with the problem. The Metropolitan Development Guide Plan indicates the existing treatment plant at Chaska will be phased out between 1985 and 2000. Raw sewage will then be pumped to a regional treatment plant east of Shakopee, Minn. This may help to reduce this potential water quality problem. Erosion and sediment collection caused by increased construction may become a significant problem unless adequately controlled. These and related problems of the Chaska area will be considered further in the Minnesota River basin survey study.

59. ALTERNATIVE METHODS OF MANAGING THE FLOODPLAIN

A comprehensive and effective plan for managing the floodplains of a particular river basin or locality may include any combination or all of the known measures for flood damage reduction or prevention. Such a program would logically include one or a mix of the following nonstructural and structural measures.

a. Nonstructural measures. -

(1) Flood warning systems.

(2) Permanent evacuation.

(3) Flood proofing of existing or new structures.

(4) Flood insurance.

(5) Floodplain regulation.

b. Structural measures. -

(1) Reservoir storage.

(2) Levees and floodwalls.

(3) Channel improvements or diversions.

60. NONSTRUCTURAL MEASURES

All nonstructural alternatives were relatively high in environmental quality but failed to adequately satisfy the social well-being objective, to show economic feasibility, or both. Flood forecasting and warning is available for the Minnesota River. Hydrologic studies of Chaska and East Creek watersheds, however, have revealed that little or no warning could be given if intense rainfall caused flash flooding on East and Chaska Creeks and, hence, the damages from flash flooding would remain severe. Evacuation of the floodplain or flood proofing existing and future development would be unacceptable both socially and economically. The cost to move flood-prone structures or flood proof them far exceeds the possible flood damages prevented. In addition, public opposition to any plan which would relocate the hundreds of residences is certain. Flood insurance has been available since 1971 in Chaska. However, less than 15 percent of the flood-prone structures in Chaska have been brought under the protection of this program. Thus, flood insurance has not received broad-based public acceptance at Chaska and, since flood damages would not be alleviated in any way, this alternative is not considered to be an adequate solution to the problem. In contrast to the above alternatives, floodplain regulation would provide significant benefits for a relatively small cost. Thus, by precluding unwise future development, potential flood damages could be frozen at present levels. However, no relief from the distressingly high flood damages to existing development would be provided. Consequently, floodplain regulation, although highly desirable, could not be expected to significantly minimize flood damages in Chaska and is considered a supplement to, rather than a substitute for, other measures which could substantially reduce flood damages. More detailed information on floodplain regulation is given in appendix E.

61. STRUCTURAL MEASURES

Nine structural flood control plans were investigated in detail for Chaska. The plans, which are all enumerated and described in appendix C and illustrated on plate 1, include flood bypass channels for East and Chaska Creeks, small reservoirs at four sites on the creeks, large reservoirs at two sites on the creeks, channel improvements for the existing streams, levees along the Minnesota River, and combinations of these measures. Large-scale reservoir development on the Minnesota River and its tributaries was also given consideration since a properly developed reservoir system could substantially reduce flood stages at Chaska. However, other measures such as creek diversions, levees, and improved interior drainage facilities at Chaska would continue to be required. Thus, large-scale reservoir development would not provide a complete solution to the flood problems.

62. Of the nine plans investigated, six were dismissed after detailed analysis since they did not provide an adequate degree of flood protection or were not economically justified. The remaining three plans which were determined to provide the most practicable and economical solution to Chaska's flood problems are described as follows:

a. Plan 8. - Bypassing flood flows from East and Chaska Creeks around heavily developed areas of Chaska, upgrading and extending the existing emergency levee, and installing adequate interior drainage facilities behind the levee.

b. Plan 10. - Construction of four headwaters reservoirs, bypassing flood flows from East and Chaska Creeks, upgrading and extending the existing emergency levee, and installing adequate interior drainage facilities behind the levee.

c. Plan 14. - Same as plan 8 except channel improvement on East and Chaska Creeks would replace flood bypass channels.

Each of the alternative plans would provide a comparable high degree of flood protection at Chaska, and all three plans demonstrate economic feasibility. Table 6 summarizes the estimated first costs, average annual costs and benefits, based on a 5 5/8-percent interest rate, and the resulting net benefits and benefit-cost ratios of each of the plans.

Table 6 - Summary of estimated costs and benefits for alternative plans

Plan	First costs ($million)	Average annual costs ($1,000)	Average annual benefits(1) ($1,000)	Net benefits ($1,000)	Benefit-cost ratio
8	9.54	579	767	188	1.3
10	12.89	765	767	2	1.0
14	10.72	624	767	143	1.2

(1) Excluding recreation benefits.

63. The three plans were then ranked on a relative scale according to how well they would satisfy the basic objectives of environmental quality, social well-being, and economic efficiency. Table 7 presents a summary of the ranking as determined by the Chaska Citizens Advisory Committee and the Corps of Engineers planners and biologists. The factors that were taken into consideration in ranking the plans under each of the three objectives are presented in table C-19, appendix C.

Table 7 - Rating of alternative plans

Rating	Environmental quality	Social well-being	Economic feasibility
High	Plan 10	Plan 8	Plan 8
	Plan 8	Plan 10	Plan 14
Low	Plan 14	Plan 14	Plan 10

64. Plan 14, channel improvements on East and Chaska Creeks, in combination with levee upgrading and extension of the existing emergency levee, rated lowest in the environmental quality and social well-being criteria. The loss of about 2½ miles of seminatural stream setting in an urban area along East Creek, the necessary relocation of 26 homes and three businesses, and the high costs of replacing every bridge which presently crosses Chaska or East Creeks in Chaska are the major reasons for the low rating. Plan 10, which is the most costly alternative rated, would include construction of four headwaters reservoirs in the East and Chaska Creek watersheds, reduced-scale flood bypass channel, and levee improvements. Implementation of the dams would intermittently inundate about 495 acres of wetlands and narrow fringes of wooded slopes causing periodic temporary displacement of wildlife and some impacts on the lower fringes of woods and brush. However, the necessary use of shallow pools for future sediment storage would increase the value of these lands for wildlife during nonflood periods. For this reason, the environmental rating was slightly higher than for plan 8 which does not include reservoir storage, and substantially higher than plan 14 in which significant permanent environmental changes would occur. Permanent deep pools could not be established in conjunction with flood protection; and therefore, social benefits of fishing and contact water sport development would not be expected with plan 10. At least one county road and the proposed relocation of U.S. Highway 212 would be adversely affected. The size of flood bypass channels would be minimized in comparison with plan 8. However, similar flood protection could be accomplished with plan 8 at a lesser cost and with fewer social changes than with plan 10. Thus, plan 8, flood bypass channels with levee upgrading and extension, is the most acceptable alternative since environmental changes resulting from the channel and levee system would not be significantly different than that of plan 10, the security and well-being of the people would be insured, and the benefits of such an undertaking would exceed the cost.

65. MAINTAIN THE STATUS QUO

Consideration was given to maintaining the status quo or recommending that no action be taken to alleviate flood problems. To do nothing would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at over $800,000 would remain and, as such, would be a severe social and economic burden to the people. Natural riverine aesthetics would probably not change significantly in designated park areas. However, as normal economic growth occurred, infringement on the river corridor in other areas by businesses, industries, and residences would likely result in degradation of the natural riverscape. Furthermore, provisions for flood protection from major floods on the Minnesota River would be

dependent on the construction of emergency levees and temporary interior drainage facilities. In view of the flash flooding that can occur at Chaska from East and Chaska Creeks, reliance on emergency measures for the entire city would be hazardous during Minnesota River floods and ineffective for flash floods on the two creeks.

66. PLAN SELECTION

The above review of available alternatives indicates that structural measures offer the only feasible flood control alternative for Chaska. Of the structural plans, plan 8 which includes a flood bypass channel on East Creek, a diversion channel on Chaska Creek, combined with upgrading and extending the existing levee system, shows the most merit. In addition to being rated the highest on social well-being and economic feasibility, the plan is strongly supported by local interests and would provide a high degree of flood protection.

67. SCALE OF DEVELOPMENT

To permit selection of the optimum level of flood protection for the Chaska area, costs and benefits were computed for several degrees of flood protection that would be provided by varying design flood discharges for the Minnesota River and East and Chaska Creeks. The optimization analysis for the selected plan was found by using the benefits and costs of protecting Chaska from varying degrees of flooding from these sources. The plan optimization data are summarized in table 8 and are shown graphically on plate C-5.

Table 8 - Plan 8 optimization summary - flood parameters at Chaska, Minn.

Flood frequency (percent)	Stage on Minnesota River (msl)	Chaska Creek discharge (cfs)	East Creek discharge (cfs)	Annual cost	Annual benefits	Net benefits	Benefit cost ratio
5.0	718.0	2,950	2,500	$489,000	$547,000	$58,000	1.1
3.0	719.7	3,500	3,000	515,000	628,000	113,000	1.2
1.0 (1)	723.0	4,700	4,350	579,000	767,000	188,000	1.3
0.5	724.9	5,600	5,400	661,000	808,000	147,000	1.2
0.25	726.5 (2)	6,800	6,500	816,000	849,000	33,000	1.0

(1) Selected level of protection and point of maximum net benefits.
(2) Equivalent to the standard project flood on Minnesota River.

68. An optimum relationship between costs and benefits exists when protection is provided for floods from East and Chaska Creeks and the Minnesota River having an average frequency of occurrence in the order

of once in 100 years. It was considered impracticable to increase the design capacity beyond intermediate regional flood protection since large additional expenditures for bridge modifications, land, and residence relocation or purchase would be necessary although such measures could be economically justified. The standard project flood on the Minnesota River is 3.5 feet above the optimum design flood elevation and 0.5 foot below the top of the levee (at optimum design). Emergency measures would be required and could be effectively employed to provide additional levee closures required by floods greater than the intermediate regional flood.

PLAN OF IMPROVEMENT

69. GENERAL DESCRIPTION

The studies for this investigation included consideration of several alternative means, structural and nonstructural, of solving the flood problems at Chaska. Based on these studies, a local protection system comprised of structural measures in combination with appropriate floodplain management measures was found to be the best flood damage reduction solution for the community of Chaska. The selected plan of improvement (plan 8) consists of 0.9 mile of diversion channel for Chaska Creek, 1.2 miles of flood bypass channel for East Creek, three drop structures on each creek, eight new bridges, upgrading 6,000 feet of existing levee, constructing 3,250 feet of new levee, installing four pumping stations, a recreation trail system, and general landscaping and tree planting in construction areas. The plan also includes floodplain regulation on East Creek and Chaska Creek upstream from the diversion channels, on East Creek near U.S. Highway 212, in ponding areas needed for interior drainage, and along the Minnesota River outside the leveed area. Plate 3 provides pertinent information as to the locations, limits, and types of improvements being proposed. The project would be designed to provide protection against the intermediate regional flood on East Creek, Chaska Creek, and the Minnesota River at Chaska.

70. FLOOD BYPASS AND DIVERSION CHANNELS

Bypassing flood flows from the natural channels of East Creek and Chaska Creek is a major element in the proposed plan (see plate 3). Approximately 1.2 miles of rock-lined, trapezoidal flood bypass channel would be used for East Creek starting at the bluff of the Minnesota River valley and ending at the Minnesota River just east of Chaska (see plate 4). The channel would pass mainly through presently undeveloped commercial or industrial zones. The use of two concrete drop structures, each about 10 feet high and 60 to 120 feet wide, would reduce design flow velocities to the point where lining the channel with rock would prevent streambank erosion. Also, a sheetpile drop structure would be required on the East Creek bypass channel at the Minnesota River to control erosion. An earthen embankment 8 to 20 feet high and 700 feet long would be constructed across the natural East Creek channel to direct flood flows into the diversion channel. Normal low flows on East Creek would be maintained in the natural channel by using a gated conduit under the diversion embankment.

76. AESTHETIC AND ENVIRONMENTAL PRESERVATION CONSIDERATIONS

In selecting each type of improvement to be used, special consideration was given to maintaining existing environmental features wherever possible. Five alternative alignments were considered for the East Creek flood bypass channel. Two of these alignments were dismissed since they would have resulted in the drainage of a large marsh and loss of valuable wildlife habitat. The other two routes would have transformed the existing seminatural stream and proposed city greenway open-space areas into a rock-lined channel. Conversely, the selected bypass channel alignment skirts the edge of the marsh and passes through primarily undeveloped industrial zones. Normal low flows would be maintained in the existing East Creek channel, thereby preserving the natural character of the stream and complementing the proposed greenway open-space system. Plate 7 provides a conceptual illustration of how the city greenway system could be combined with the proposed East Creek flood bypass structure to enhance the natural beauty of the area. A similar conceptual design for the Chaska Creek diversion channel is illustrated on plate 8. Removal of the existing emergency levee between Courthouse Lake and the Carver County Courthouse would improve the view of the lake. The proposed levee around the lake would be contoured with surplus material from channel excavation, then landscaped and planted with trees and shrubs. Also, the riverward side of the levee would be seeded with native prairie grass species which would provide wildlife habitat and require virtually no maintenance. The city of Chaska, with State and Federal aid, is acquiring 500 acres for parkland and open space. Sizable portions will be wooded lowland and marshland which will serve as greenbelts and wildlife refuges. Recreation and environmental appreciation trails are planned in these areas to fulfill recreational demands and to serve nature study enthusiasts. By utilizing the concepts and landscaping techniques mentioned above and recognizing the potential of the city's greenbelt and open-space policy, a long-term environmental enhancement of many areas in Chaska would be possible.

ESTIMATES OF FIRST COST

77. The total estimated first cost of the proposed project, based on February 1973 prices, is $9,543,000. Allowances were made for the cost of engineering, overhead, inspection, and contingencies. Details of the estimate are included in appendix D and are summarized in table 9. Contingencies are included in each principal feature in the summary.

Table 9 - Summary of estimated first costs (February 1973 price levels)

Item	First cost
Lands and damages	$521,000
Channel diversion and flood bypass	2,877,000
Levees and relief well system	2,073,000
Pumping plants	1,386,000
Recreation facilities	36,000
Relocations	
Railroads	491,000
Highway bridge removal and protection	41,000
Road and bridge modification	832,000
Utilities	108,000
Engineering and design	765,000
Supervision and administration	413,000
Total	9,543,000(1)

(1) Exclusive of interim survey study costs, $120,000.

ESTIMATE OF ANNUAL CHARGES

78. The total annual charges comprising interest and amortization and annual maintenance, operation, and replacement costs total $579,000. The estimated annual charges, summarized in table 10, are based on an interest rate of 5 5/8 percent and a project economic life of 100 years. Also reflected in the annual charges is the interest on the project investment during an assumed 2-year construction period. An itemized breakdown of the annual charges for operation, maintenance, and major replacements is given in appendix D.

Table 10 - Estimated annual charges

Economic investment	
Financial cost, initial construction	$9,543,000
Interest during construction	389,000
Total economic investment	9,932,000
Annual charges	
Interest and amortization	561,000
Operation, maintenance, and major replacement	17,000
Recreation trail maintenance	1,000
Total annual charges	579,000

ESTIMATE OF BENEFITS

79. FLOOD CONTROL AND RELATED BENEFITS

Based on February 1973 price levels, a 100-year economic life (1980-2080) and a 5 5/8-percent interest rate, the total average annual flood control benefits attributable to the proposed improvements at Chaska are $709,000. The benefits represent the difference between the flood damages that could be expected without and with the proposed improvements and include protection of more than 540 residences, 47 businesses and industries, and three public buildings. The estimated average annual flood damages remaining with the project or residual damages are $97,000. The benefit analysis also recognizes flood control related benefits which amount to $58,000 annually. These benefits include flood proofing cost savings to new development and to redevelopment and increased land utilization, all of which would be attributable to the project. The analysis includes proper allowances for future economic growth in the floodplain and recognizes the effect that Minnesota floodplain regulations will have on flood-prone areas in Chaska. Detailed information on the benefit evaluation is included in appendix C.

80. RECREATION BENEFITS

The proposed recreation trails around Courthouse Lake and on top of the levee would provide for over 5,000 recreation-days of use soon after project completion and ultimately produce over 15,000 recreation-days of visitation. Bicycling, nature walks, walking for pleasure, bird watching, wildlife photography, and hiking are the primary uses expected and would provide average annual benefits of $4,000. Linking the proposed trails to the Minnesota River Valley trail system and the Jonathan trail system could further enhance recreation. Additional study will be required during postauthorization studies to determine the magnitude of these benefits since plans for the Minnesota River valley and Jonathan trail systems have not been finalized.

81. INTANGIBLE BENEFITS

In addition to the monetary benefits that would accrue through reduction of flood damages at Chaska, very important intangible benefits can be credited to the proposed improvements. These include reduction of hazard to life from flash flooding, elimination of human suffering and strain by all members of the community, reduction in the menace of epidemics caused by damage to sewer and water systems, and prevention of interruptions to normal social and business activities. Also, residences and businesses in the protected area would become eligible for federally guaranteed loans. Aesthetics in the Courthouse Lake area and along the existing levee would be improved. Possible major flood damages that would be prevented by the project and that are difficult to assess in monetary terms are the damages that would accrue from the disruption of electric power,

the loss of the Chaska fire station, the loss of the Carver County sheriff's headquarters, the disruption of communications and transportation facilities, and the loss of irreplaceable records at the Carver County Courthouse.

82. SUMMARY OF AVERAGE ANNUAL BENEFITS

Average annual benefits attributable to the proposed plan of improvement are summarized in table 11.

Table 11 - Summary of average annual benefits

Type of benefit	Average annual equivalent benefits 1980-2080
Urban flood damage reduction	$709,000
Improved land utilization	58,000
Recreation	4,000
Total benefits	771,000

ECONOMIC JUSTIFICATION

83. Comparison of the total average annual benefits of $771,000 with the total average annual economic cost of $579,000 indicates a benefit-cost ratio for the overall project of 1.3. The benefits for each project purpose compared with the separable cost of adding that purpose to the plan are indicated in table 12. As shown, the proposed improvements are economically justified.

Table 12 - Summary of separable costs and benefits for project purposes

Project purpose	Benefits	Separable annual costs	Benefit-cost ratio
Flood control	$767,000	$576,000	1.3
Recreation	4,000	3,000	1.3
Total	771,000	579,000	

LOCAL COOPERATION REQUIREMENTS

84. The requirements of local cooperation for the proposed project are in accordance with the provisions of the Flood Control Act of 1936 and Section 4 of the Flood Control Act of 1944 (16 u.s.c. 460 d) as amended by Section 207 of the Flood Control Act of 1962. The requirements are that local interests:

a. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction of the project.

b. Provide the necessary lands for recreation development and, where the appraised value of those lands furnished amounts to less than 50 percent of the total first cost of recreation development, sufficient additional contributions shall be provided to bring the non-Federal share to at least 50 percent of the total first cost of recreation development.

c. Hold and save the United States free from damages due to the construction works.

d. Maintain and operate the recreation facilities and the project after completion in accordance with regulations prescribed by the Secretary of the Army.

e. Prevent any encroachment on the existing East Creek and Chaska Creek channels, constructed works, floodways, and ponding areas that would interfere with the proper functioning of the project and, if ponding is impaired, provide promptly and without cost to the United States substitute storage or equivalent pumping capacity.

f. Provide without cost to the United States all alterations and relocations of existing improvements including buildings, utilities, sewers, highway bridges, roads, and any other special facilities resulting in a local betterment, except as otherwise warranted for special reasons.

g. Implement and administer floodplain regulations in accordance with State law where intermediate regional flood protection is not provided.

APPORTIONMENT OF COSTS

85. FIRST COSTS

Based on existing criteria and policies, costs associated with construction of the flood bypass channel, diversion channels, levees, interior drainage facilities, railroad bridge modifications, and environmental treatment are assigned to the Federal Government. Local interests would furnish all lands and rights-of-way; assume all highway bridge modification costs; make necessary relocations of roads and utilities, except as otherwise warranted for special reasons; and maintain the project after completion. The distribution of costs, including appropriate engineering, design, supervision and administration costs is shown in table 13. Wherever relocated utility lines pass beneath or

through the proposed construction works and are integral parts of the project structures within the rights-of-way of the project, they have been recognized as a Federal cost. The construction of a bridge over East Creek on Minnesota Highway 41 would be necessary to protect the East Creek flood bypass structure from flood waves that could be generated by a collapse of the existing highway embankment. The cost for removal of the existing culvert has been included in table 13 below as a Federal cost. Construction of the bridge is included as a non-Federal responsibility. Costs associated with the recreation trails have been divided into Federal and non-Federal cost shares in accordance with Public Law 89-72.

Table 13 - Apportionment of project costs among interests

Item	First costs (1)		
	Federal	Non-Federal	Total
Lands and damages		$521,000	$521,000
Channel diversion and flood bypass	$3,337,000		3,337,000
Levees and relief wells system	2,405,000		2,405,000
Pumping plants	1,608,000		1,608,000
Recreation facilities (2)	18,000	18,000	36,000
Relocations			
Railroads	569,000		569,000
Highway culvert and bridge removal and protection	47,000		47,000
Road and bridge modification		901,000	901,000
Utilities	30,000	89,000	119,000
Total	8,014,000	1,529,000	9,543,000

(1) Includes engineering and design, supervision and administration.

(2) Cost apportionment determined by a 50-percent Federal and 50-percent non-Federal cost sharing.

86. The Federal Highway Administration has informed the Chief of Engineers that Federal-aid highway funds are not available to defray any part of the cost of altering Federal-aid highways for flood control projects where local interests are required to assume the cost of such adjustments as part of the local cooperation.

87. ANNUAL CHARGES

All maintenance, operation, and replacement costs for the proposed improvement are assigned to non-Federal interests. The estimated annual charges, based on 5 5/8-percent interest rate and 100-year project economic life, are given in table 14. Interest during an assumed 2-year construction period has been appropriately applied to the annual charges. Appendix D presents additional information on maintenance, operation, and replacement costs.

Table 14 - Annual charges

Federal annual charges		
Interest and amortization		
Recreation facilities ($18,000 X 0.05649)		$1,000
Flood control works ($8,385,000)		474,000
Non-Federal annual charges		
Interest and amortization		
Recreation facilities ($18,000 X 0.05649)	$1,000	
Flood control works ($1,511,000 X 0.05649)	85,000	
Maintenance, operation and replacement		
Recreation facilities	1,000	
Flood control works	17,000	
Total non-Federal annual charges		104,000
Total project annual charges		579,000

COORDINATION WITH OTHER AGENCIES AND INTERESTS

88. Coordination between Federal, State, and local interests has been an important element in this study. Special coordination has been maintained with the Minnesota Department of Natural Resources, the Minnesota Department of Highways, and the city of Chaska in an effort to reach a mutually agreeable solution to the flood problems at Chaska. All other interested Federal and State agencies were informed of the initiation of this investigation and have been contacted during development of the plan of improvement on all phases that would affect their interests. Mid-course during the study, a field inspection tour of the project area and a briefing to describe alternative water-resource management plans being considered was held at Chaska to acquaint agency representatives with the areas affected and the progress of the study. Meetings with a locally organized citizens advisory committee were held during the investigation to insure inclusion of public preferences and desires in the plan. A public meeting was held at Chaska on 7 June 1973 and was attended by about 50 people. The proposed plan of improvement was presented to all interested parties to ascertain their views and to insure that the plan would be acceptable. During the meeting, local interests again stated their preference for the plan as proposed. A statement from the city of Chaska, presented at the meeting, and a resolution from Carver County submitted subsequent to the meeting endorse the proposed plan. The Bureau of Sport Fisheries and Wildlife submitted a letter expressing concern for wetlands which may be drained directly and indirectly by the proposed project. The Environmental Protection Agency stated its wetland policy. The Sierra Club opposed the proposed project and any project which involves changes to drainage, channelization, or floodplain use until a complete study has been made on all contributing

factors of the Mississippi River flood of 1973. The Minnesota Department of Natural Resources, however, found no objections to the plan as proposed. Resolutions expressing Chaska's willingness to provide the required local cooperation together with comments from other agencies are presented in appendix H.

DISCUSSION

89. This investigation has verified the seriousness of the urban flood problems in the city of Chaska. Flash floods on East Creek and Chaska Creek could inundate major portions of the community within hours of an intense rainstorm over the creek watersheds. Such flash flooding would be a severe threat to the life and security of the residents of the city. Similarly, the Minnesota River poses a severe flood hazard to the community, as was evidenced in 1965 when several hundred residences and businesses susta ned major flood damage. Since 1965, the emergency levees along th Minnesota River have been raised, although they are not tied to high ground at either end of the city. Experience gained during the 1969 flood showed that permanent works are needed to provide protection against Minnesota River flooding. At high river stages, seepage flows could undermine the emergency levee and cause it to collapse, flooding the protected area to depths exceeding 15 feet within minutes. This levee has also intensified the flood threat from East and Chaska Creeks since overflow from the creeks could pond behind the levee, damaging several hundred homes and businesses. The city in cooperation with the State of Minnesota has implemented a floodplain regulation program along the Minnesota River within the city. The East and Chaska Creek floodplains are not currently regulated since the required engineering data to delineate the floodplain have not been available prior to this report.

90. Fourteen alternative nonstructural and structural methods for managing floodplain areas in Chaska were given detailed analysis during this study. In addition, consideration was given to the potential effects which a system of large reservoirs on the Minnesota River and its tributaries might have on flood stages at Chaska. Preliminary hydrologic analyses indicated that a system of reservoirs could have significantly reduced flood stages on the Minnesota River at Chaska. However, flooding on East and Chaska Creeks and major interior drainage problems behind the levee at Chaska would have remained unresolved. Furthermore, strong opposition has been voiced against such a reservoir system. Since the reservoirs, if ever constructed, would only increase the degree of flood protection at Chaska, other flood damage reduction measures were deemed necessary. Based on the examination of the various structural and nonstructural alternatives, the proposed flood bypass and diversion channels, levees, interior drainage improvements, and appropriate floodplain zoning measures would provide the best overall solution to the flood problems at Chaska.

91. Most of the environmental impact of the proposed project would be to an urban rather than a natural environment. The proposed project would result in human welfare gains associated with the reduction in water damages to personal property and numerous important intangible benefits such as avoidance of severe human hardship, suffering, and hazard of epidemics resulting from large floods. Although the levee alignment would generally follow that now occupied by emergency works, the natural environment adjacent to Chaska would be affected in those portions of the present floodplain where levee extensions would be constructed and the existing vegetation removed. The flood bypass channel on East Creek and the diversion channel on Chaska Creek would pass through mainly undeveloped industrial lands and thus not pose any serious environmental problems. To improve the appearance of proposed improvements, general landscaping and architectural treatments would be used in areas exposed to considerable public view and use. A draft environmental statement was prepared concerning the proposed plan of improvement and was coordinated with concerned Federal, State, and local interests.

92. The proposed project recreation development consists of a levee trail system and community park at Courthouse Lake in Chaska. Recreational use would consist of nonmotorized trail use, mainly bicycling, hiking, wildlife photography, nature walks, bird watching, and walking for pleasure. The levee would be aesthetically treated to blend into the natural environment by utilization of native prairie grass and overburden areas. The overburden areas, or warps would allow a root-free zone permitting establishment of large native trees. Local interests have indicated a desire and willingness to participate in constructing the proposed trails. They have also indicated an interest in developing a trail system along the Chaska Creek diversion channel and along East Creek to allow interconnection with other contemplated trail systems. However, local planning has not progressed to the point where a detailed trail system can be identified. Further consideration will be given to recreation needs during postauthorization studies.

93. The proposed plan of improvement includes no lands or property which fall within the provisions of Executive Order 11593, 13 May 1971, Protection and Enhancement of the Cultural Environment.

EFFECTS ASSESSMENT

94. In accordance with guidelines for the assessment of economic, social, and environmental effects of civil works projects as contained in Section 122 of the Flood Control Act of 1970, all significant beneficial and adverse effects of the proposed plan were fully considered.

Significant effects of the alternative plans considered are summarized in paragraphs 60 through 65 of the main report and discussed in detail in appendixes C and F. For the selected plan, expected project-related economic, social, and environmental effects were evaluated for both with and without project conditions over a 100-year period. Table C-19 shows some of the more significant socioeconomic effects and environmental effects of all considered alternatives should they be implemented. The proposed plan would protect Courthouse Lake from flooding by the Minnesota River and would be beneficial to local recreation and the lake fishery. In addition, a recreation trail system along the levee, plantings, and aesthetic treatment of the structures should offset identified adverse effects of the plan.

STATEMENT OF FINDINGS

95. I have reviewed and evaluated in light of the total public interest the significant reports, studies, and other documents compiling data concerning the proposed action, appended to, summarized in, or referenced in the report, as well as the views of other agencies and the public relative to various alternatives affecting the balance of values in accomplishing flood damage reduction in Chaska. I have studied and analyzed the possible consequences of these alternatives, considering engineering feasibility, environmental effects, economic factors, and social well-being. I have also considered the costs and means of eliminating, minimizing, or ameliorating possible adverse environmental, social, and economic effects including:

a. Water pollution.

b. Destruction or disruption of man-made and natural resources, aesthetic values, community cohesion, and the availability of public facilities and services.

c. Adverse employment effects and tax on property value losses.

d. Injurious displacement of people, businesses, and farms.

e. Disruption of desirable community and regional growth.

96. Recognizing that evaluation of the intended project purposes involves certain adverse consequences which have been explained and analyzed in this report, I find that the action leading to such adverse effects is nonetheless justified by other considerations as discussed above.

97. In light of these findings, I am convinced that the action as proposed in this recommendation is based upon consideration of all appropriate alternative courses of action for achieving the stated objectives; that the action is fully consistent with national policy, laws, and administrative directives; and that on balance the total public interest is best served by its implementation.

CONCLUSIONS

98. The proposed plan of management and improvement for flood damage reduction and recreation improvements at Chaska consists of a flood bypass channel on East Creek, a diversion channel on Chaska Creek, and levee and interior drainage improvements along the Minnesota River, a recreation trail system, and appropriate floodplain regulation measures in remaining floodplain areas of Chaska in accordance with the existing State approved city floodplain zoning ordinance. This plan was proven to be the best overall plan and is highly desired by the residents of Chaska.

99. As a matter of urgency, it is considered essential that the city of Chaska immediately update the city floodplain zoning program needed for East and Chaska Creeks in accordance with State law to prevent further unwise development within floodplain areas at Chaska. Such measures would prevent encroachment on proposed works and would assure that yet to be developed areas beyond the proposed project boundaries would not require flood protection at a future date. In view of the serious potential for loss of life due to flash flooding on East Creek and Chaska Creek, or the possible failure of the existing levee during a major flood on the Minnesota River, the city of Chaska should develop an emergency evacuation plan and warning system to alert residents in case of an imminent flood disaster. This would be especially important on East Creek where a flood wave generated by the collapse of the Minnesota Highway 41 road embankment during an intense rainstorm could surge down the narrow stream valley and enter a mobile home park and a residential area of Chaska within minutes.

100. The currently proposed flood bypass channel, diversion channel, levee improvements, and related features are economically justified and would contribute toward the solution of flood problems in the Minnesota River basin. In addition, the proposed plan of improvement would be fully compatible with a comprehensive plan of water resource management and development for the Upper Mississippi River basin.

RECOMMENDATIONS

101. I recommend that the United States construct a flood bypass channel on East Creek, a diversion channel on Chaska Creek, and levee and interior drainage improvements along the Minnesota River at Chaska, Minn., for flood control, generally in accordance with the plan proposed herein, and with such modifications thereof as in the discretion of the Chief of Engineers may be advisable at an estimated Federal first cost of $8,014,000; non-Federal first cost of $1,529,000; and non-Federal annual maintenance, operation, and replacement costs of $18,000; provided that, prior to construction, local interests furnish assurances satisfactory to the Secretary of the Army that they will:

a. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for the construction of the project, now estimated to cost $521,000.

b. Provide the necessary lands for recreation development and where the appraised value of those lands furnished amounts to less than 50 percent of the total first cost of recreation development, sufficient additional contributions shall be provided to bring the non-Federal share to at least 50 percent of the total first cost of recreation development, now estimated at $18,000.

c. Hold and save the United States free from damages due to the construction works.

d. Maintain and operate the recreation facilities and the project after completion in accordance with regulations prescribed by the Secretary of the Army, now estimated to cost $18,000 annually.

e. Prevent any encroachment on the existing East Creek and Chaska Creek channels, constructed works, floodways, and ponding areas that would interfere with the proper functioning of the project and, if ponding is impaired, provide promptly and without cost to the United States substitute storage or equivalent pumping capacity.

f. Provide without cost to the United States all alterations and relocations of existing improvements including buildings, utilities, sewers, highway bridges, roads, and any other special facilities resulting in a local betterment, except as otherwise warranted for special reasons, now estimated at $990,000.

g. Implement and administer floodplain regulations in accordance with State law where intermediate regional flood protection is not provided.

RODNEY E. COX
Colonel, Corps of Engineers
District Engineer

R 16 Apr 74

NCDPD-PF (Aug 73)   1st Ind
SUBJECT: Feasibility Report for Flood Control, Minnesota River
at Chaska, Minnesota

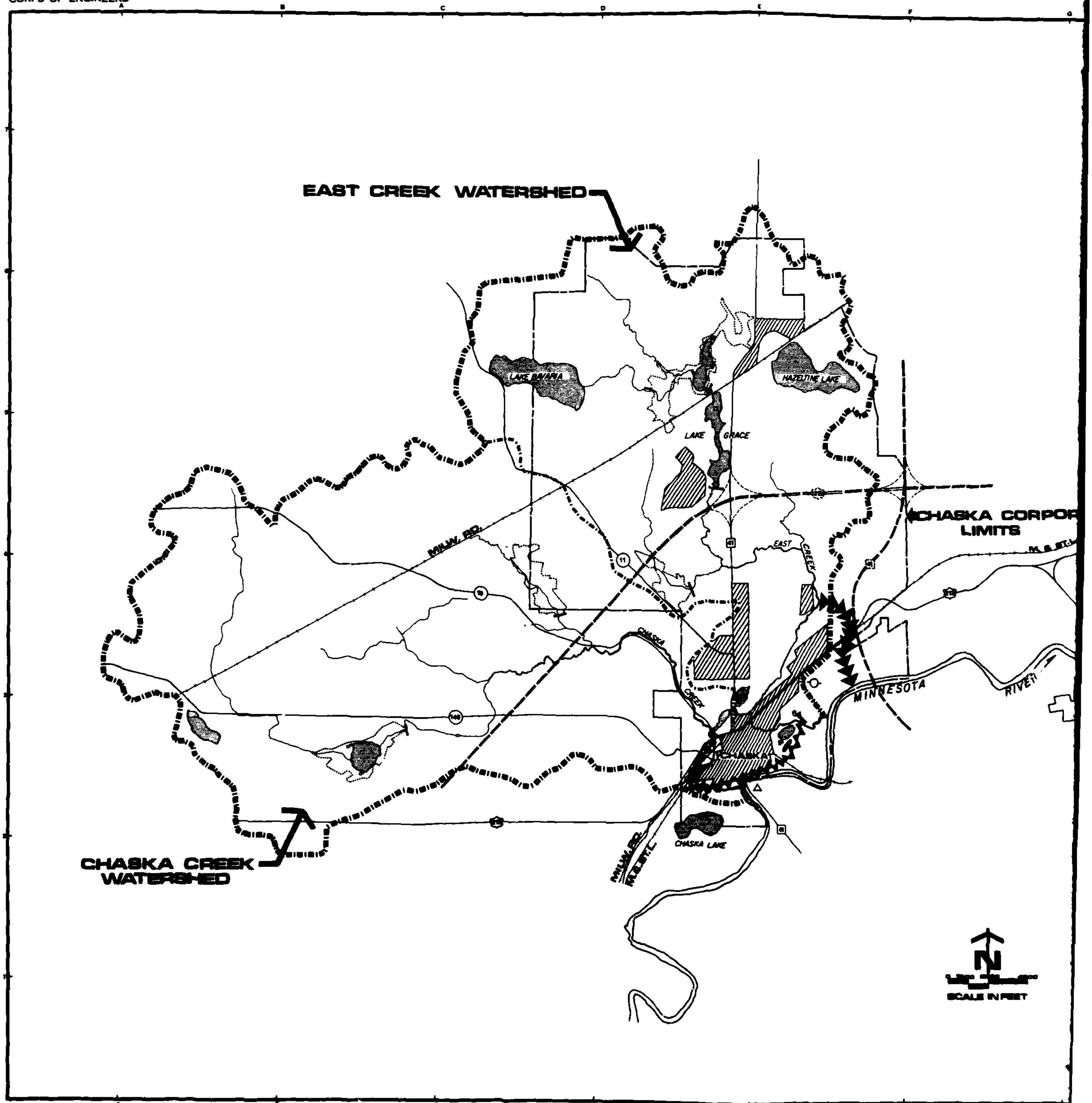
DA, North Central Div., CE, Chicago, Ill. 60605   10 December 1973

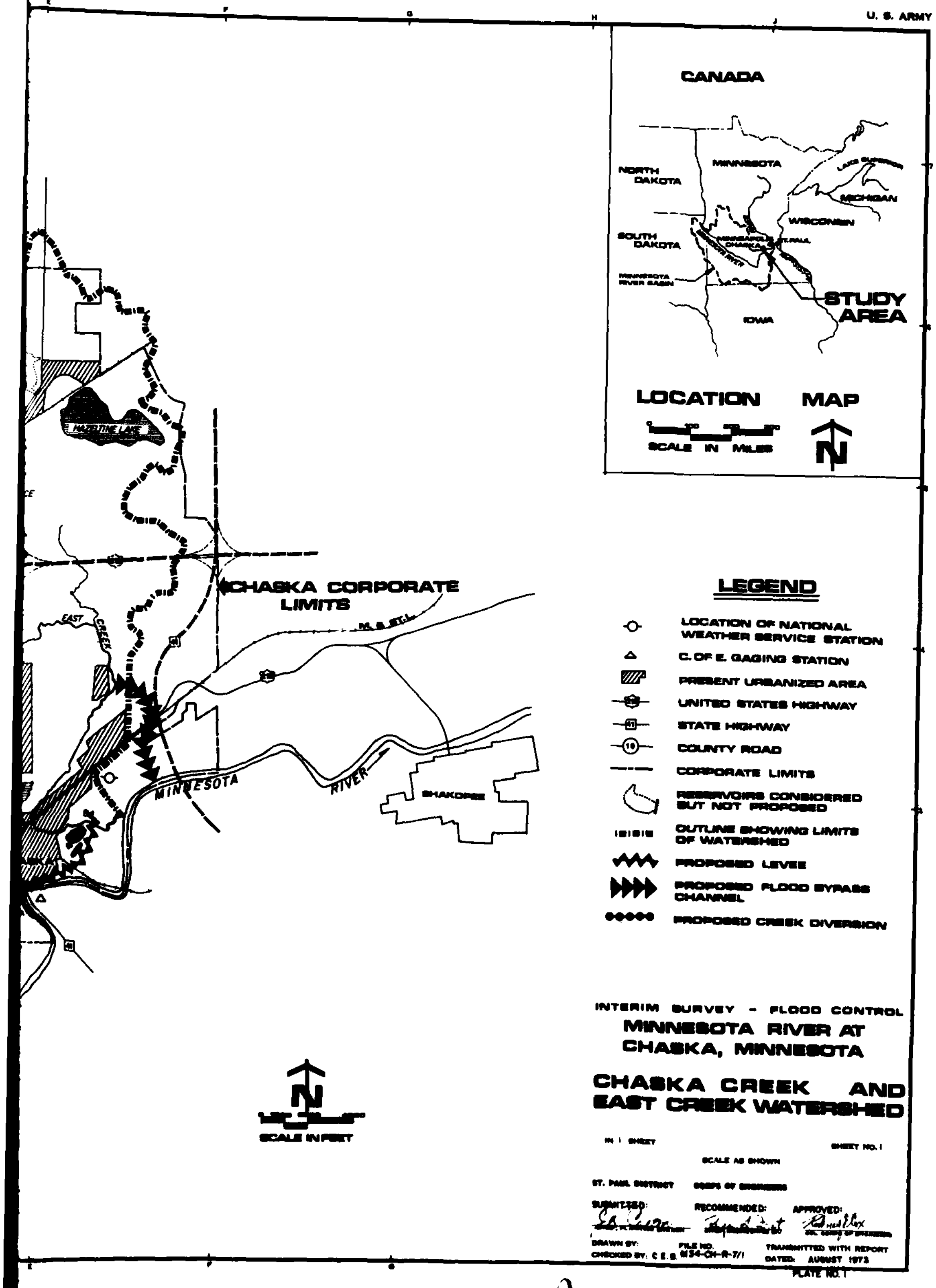
TO: HQDA (DAEN-CWP-C) WASH DC 20314

I concur in the conclusion and recommendation of the District Engineer.

ERNEST GRAVES
Major General, USA
Division Engineer

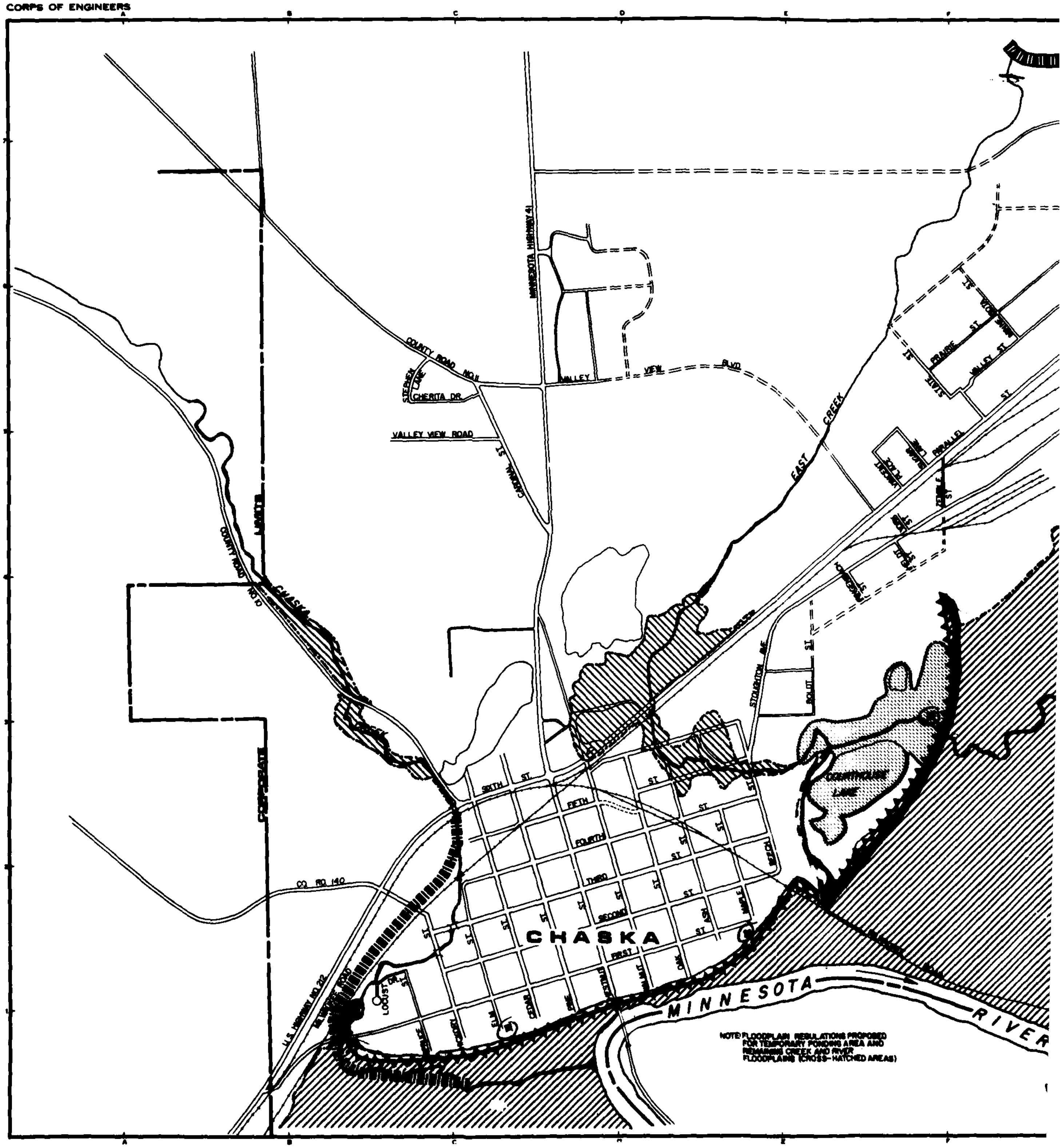
CORPS OF ENGINEERS

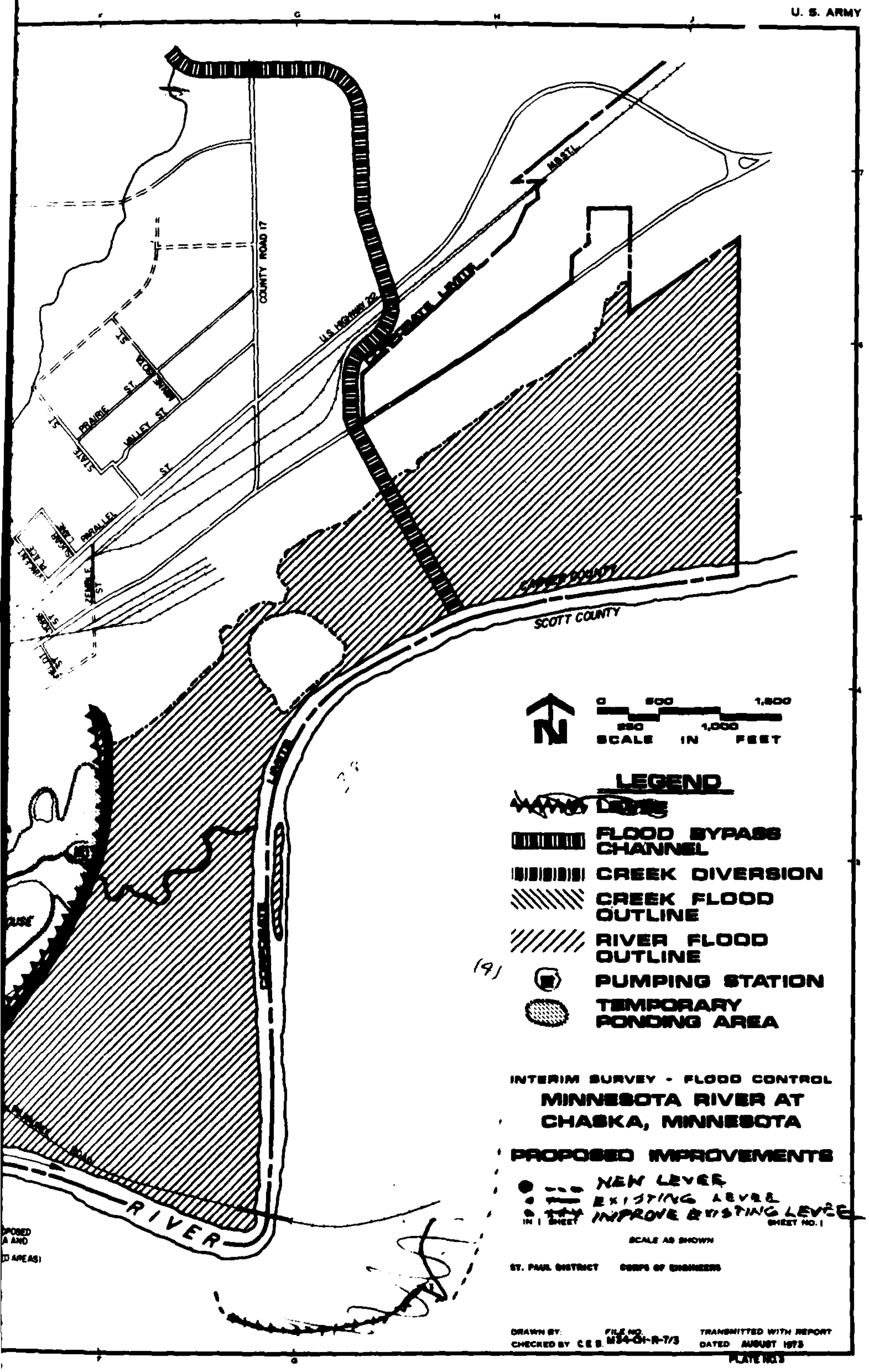



U. S. ARMY
CANADA
NORTH DAKOTA
MINNESOTA
MICHIGAN
WISCONSIN
SOUTH DAKOTA
IOWA
STUDY AREA
LOCATION MAP
SCALE IN MILES
HAZELTINE LAKE
CHASKA CORPORATE LIMITS
EAST CREEK
MINNESOTA RIVER
SHAKOPEE
SCALE IN FEET
LEGEND
LOCATION OF NATIONAL WEATHER SERVICE STATION
C. OF E. GAGING STATION
PRESENT URBANIZED AREA
UNITED STATES HIGHWAY
STATE HIGHWAY
COUNTY ROAD
CORPORATE LIMITS
RESERVOIRS CONSIDERED BUT NOT PROPOSED
OUTLINE SHOWING LIMITS OF WATERSHED
PROPOSED LEVEE
PROPOSED FLOOD BYPASS CHANNEL
PROPOSED CREEK DIVERSION
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
CHASKA CREEK AND EAST CREEK WATERSHED
IN 1 SHEET
SHEET NO. 1
SCALE AS SHOWN
ST. PAUL DISTRICT
SUBMITTED:
RECOMMENDED:
APPROVED:
DRAWN BY:
CHECKED BY: C.E.S.
FILE NO. M34-CH-R-7/1
TRANSMITTED WITH REPORT
DATED: AUGUST 1973
PLATE NO. 1

2

CORPS OF ENGINEERS

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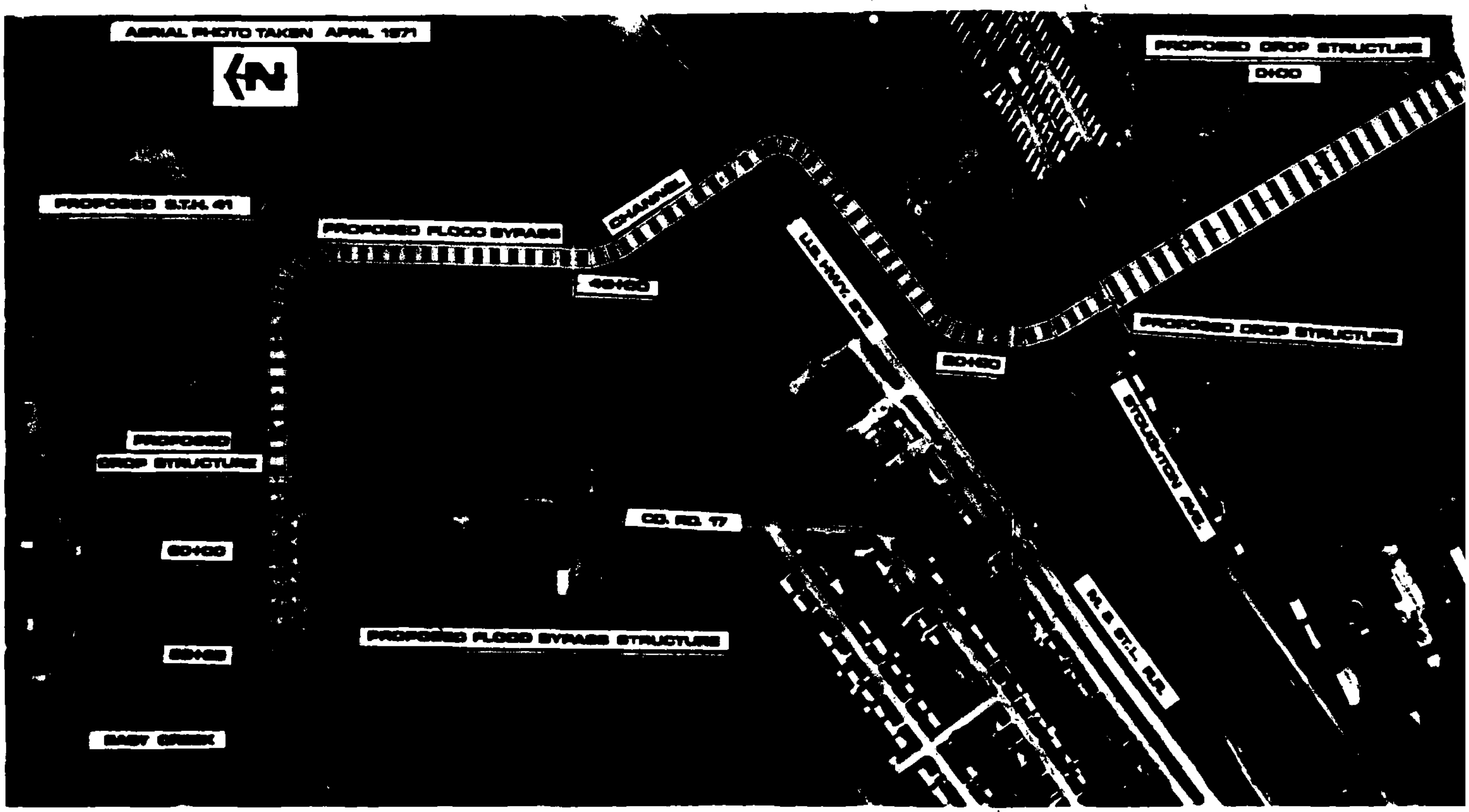
COUNTY ROAD 17
CORPORATE LIMITS
PRAIRIE ST
VALLEY ST
STATE ST
PARALLEL
SCOTT COUNTY
RIVER
0 500 1,500
250 1,000
SCALE IN FEET
LEGEND
FLOOD BYPASS CHANNEL
CREEK DIVERSION
CREEK FLOOD OUTLINE
RIVER FLOOD OUTLINE
PUMPING STATION
TEMPORARY PONDING AREA
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
PROPOSED IMPROVEMENTS
NEW LEVEE
EXISTING LEVEE
IMPROVE EXISTING LEVEE
SHEET NO. 1
SCALE AS SHOWN
ST. PAUL DISTRICT CORPS OF ENGINEERS
DRAWN BY
CHECKED BY C.E.S.
FILE NO. M34-CH-R-7/3
TRANSMITTED WITH REPORT DATED AUGUST 1973
PLATE NO. 3

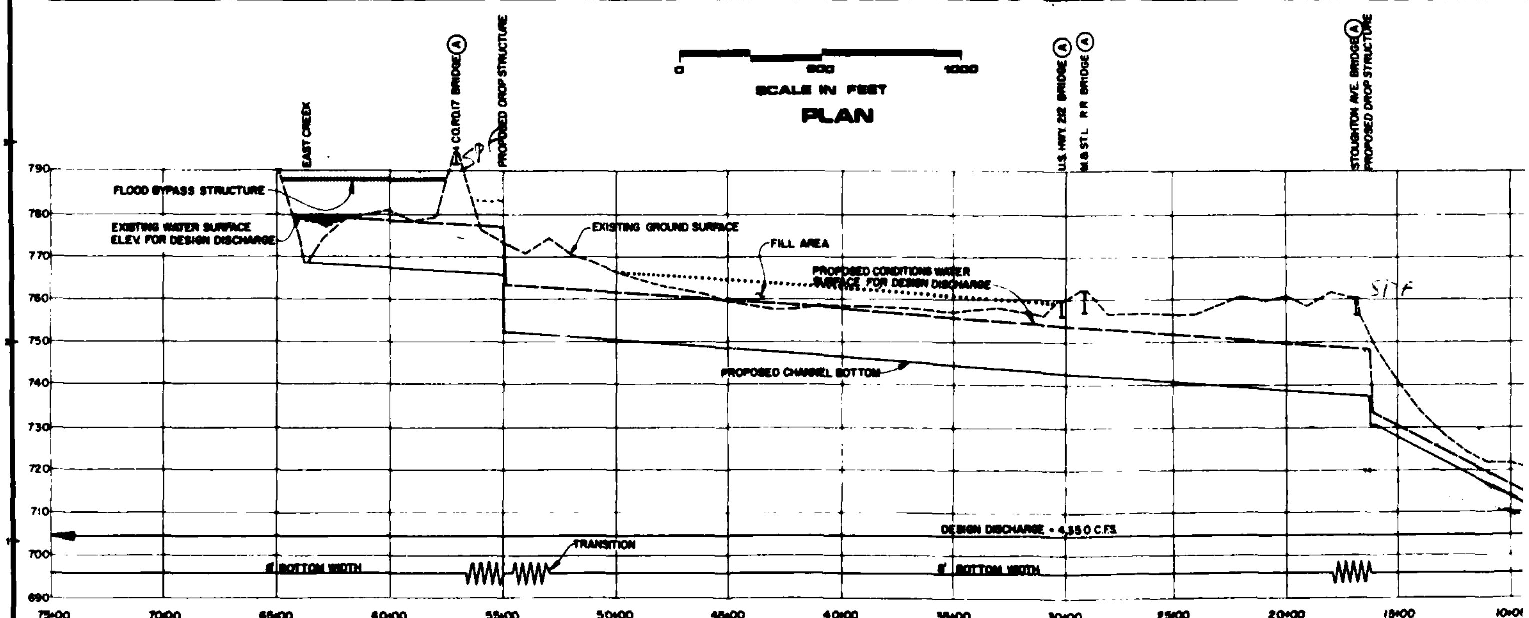
2

CORPS OF ENGINEERS



SCALE IN FEET

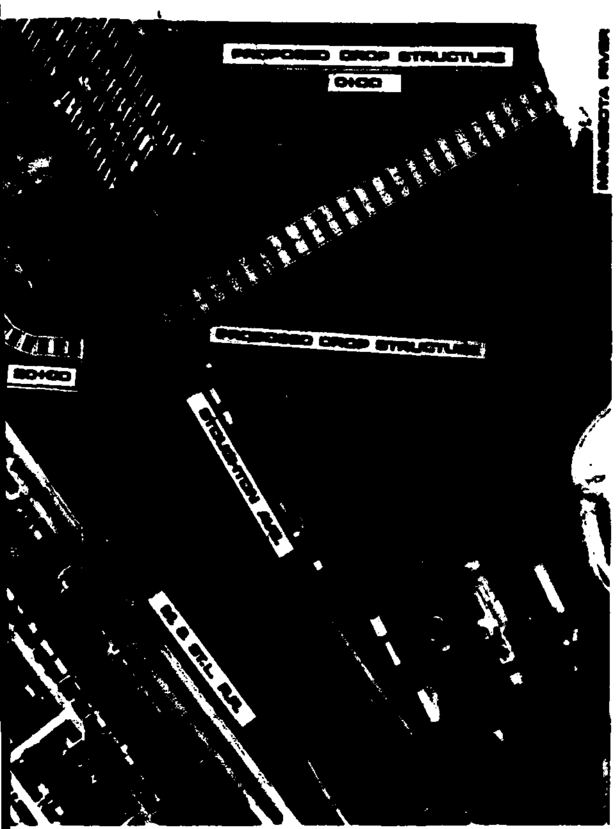
PLAN

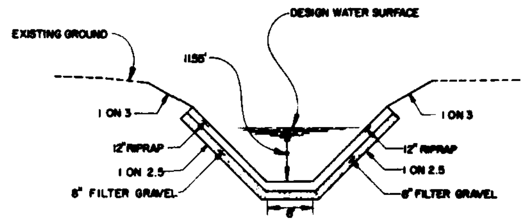


STATIONING IN FEET ABOVE THE MINNESOTA RIVER
PROPOSED ALIGNMENT

PROFILE

U. S. ARMY





TYPICAL FROM STA. 16+20 TO 63+65
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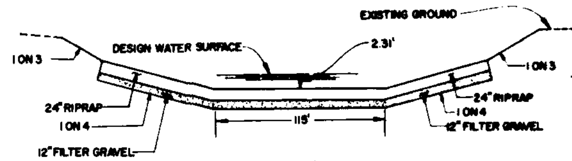

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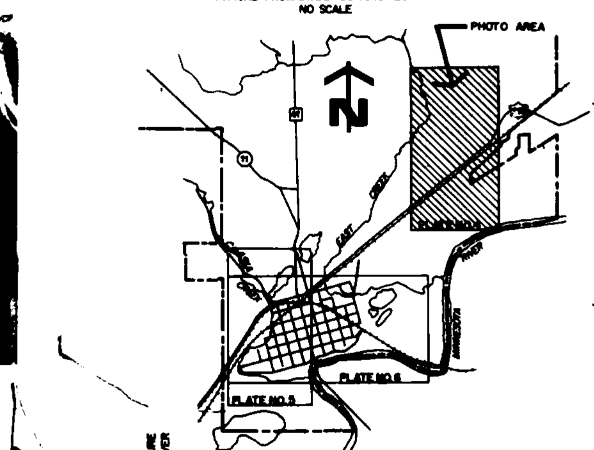
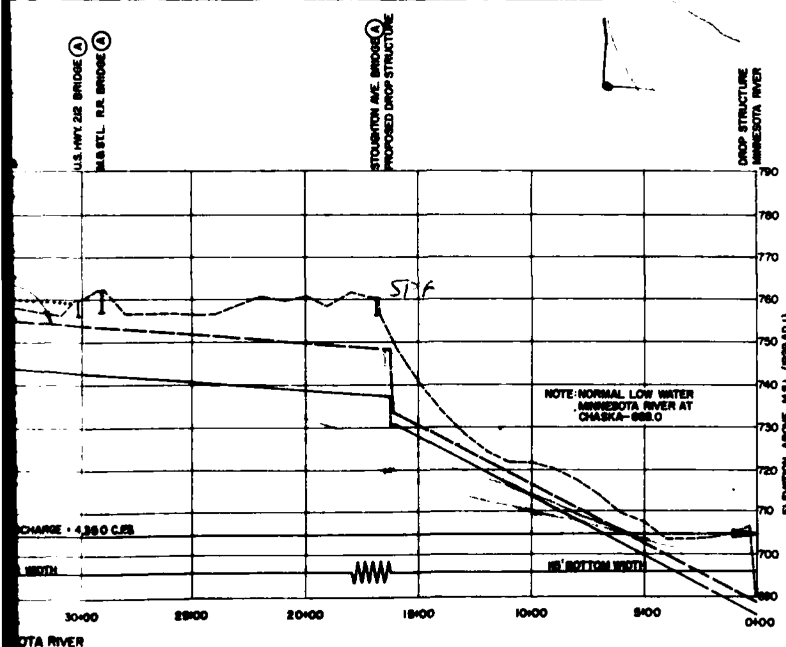


INDEX MAP OF
CHASKA, MINNESOTA



BRIDGE LEGEND

(A) PROPOSED BRIDGE

INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT
CHASKA, MINNESOTA
PROPOSED EAST CREEK
FLOOD BYPASS CHANNEL
PLAN & PROFILE

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

ST. PAUL DISTRICT CORPS OF ENGINEERS

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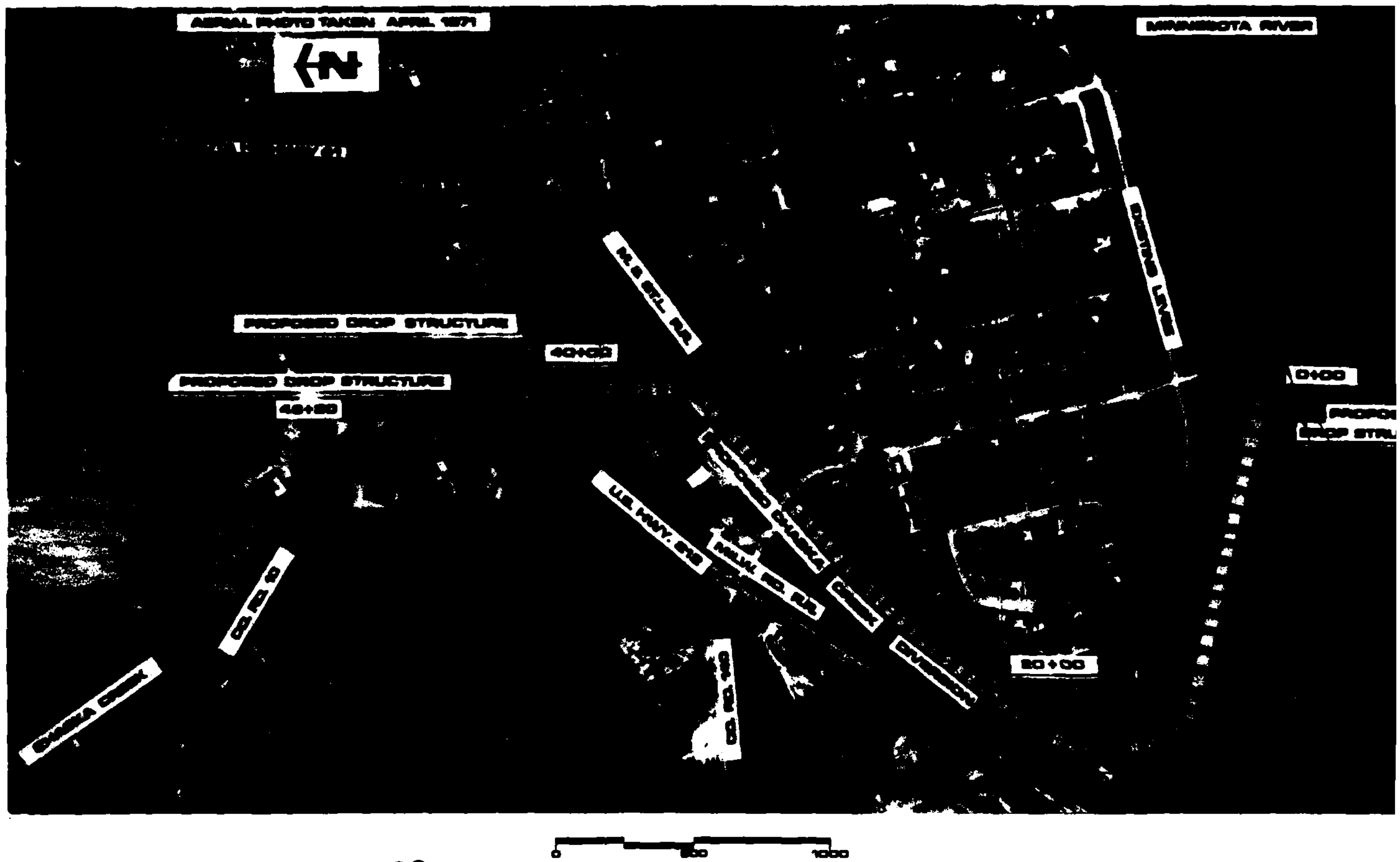
CHECKED BY: C.E.S.
FILE NO. M34-CH-R-7/4
TRANSMITTED WITH REPORT
DATED: AUGUST 1973

PLATE NO. 4

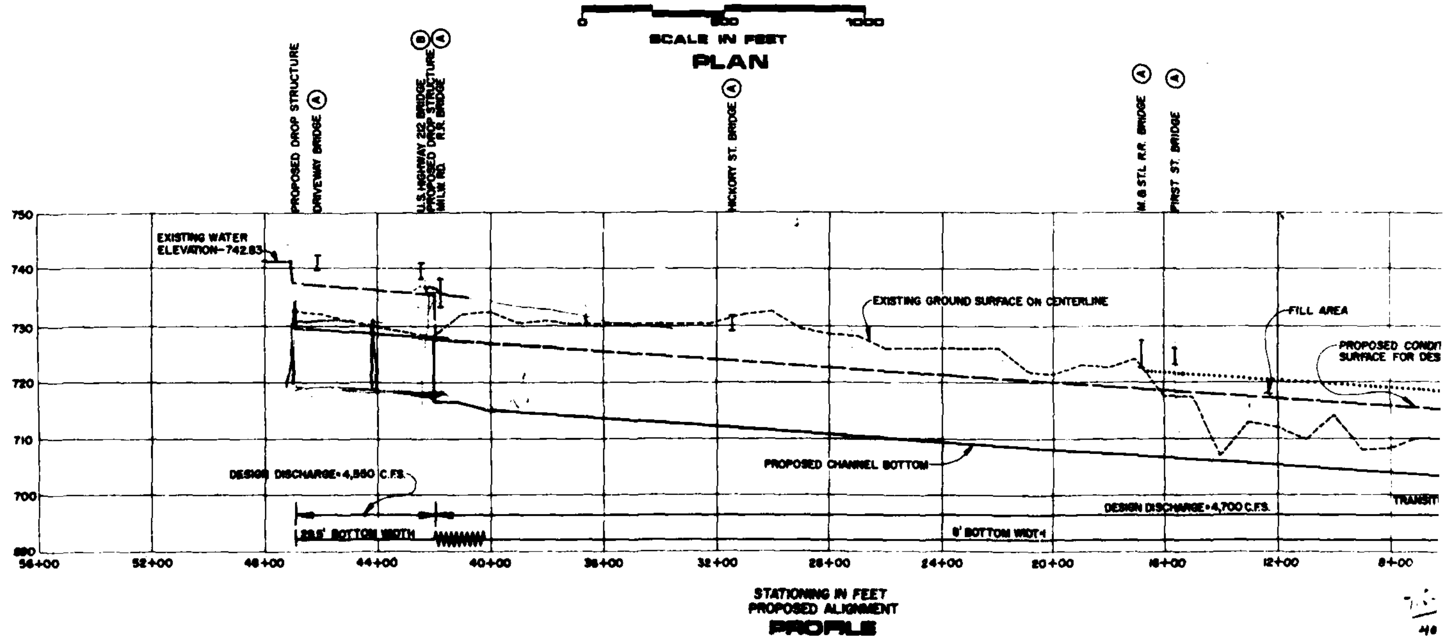
2

CORPS OF ENGINEERS



SCALE IN FEET

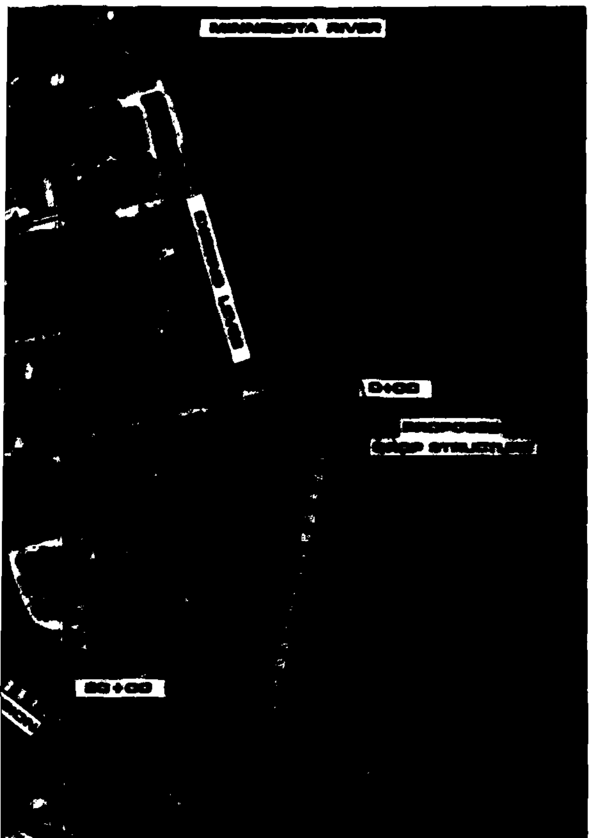
PLAN

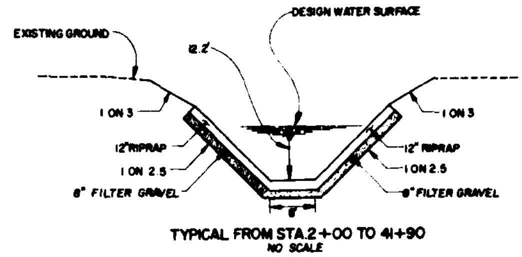


STATIONING IN FEET
PROPOSED ALIGNMENT

PROFILE

U. S. ARMY





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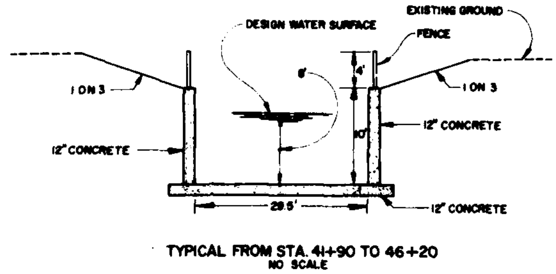

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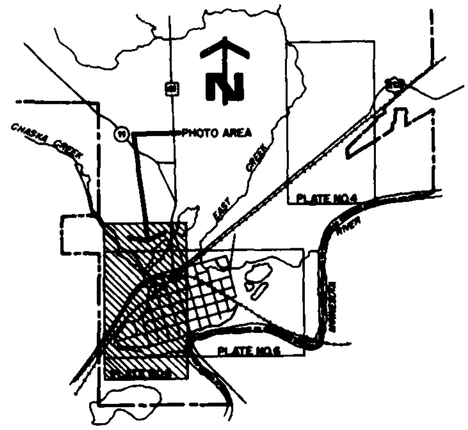
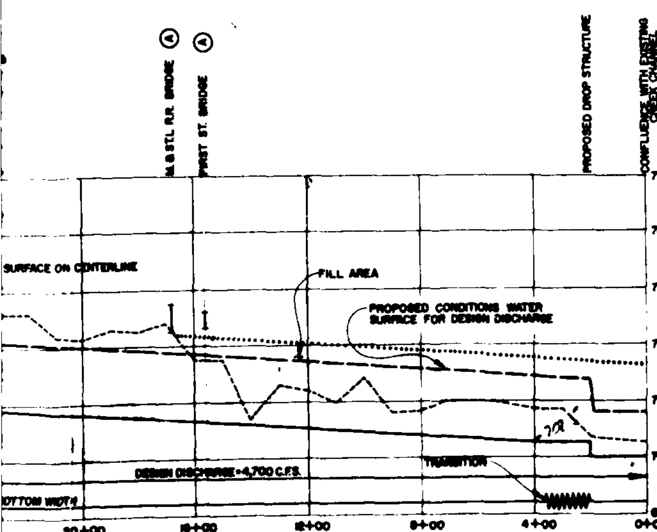


INDEX MAP OF
CHASKA, MINNESOTA

BRIDGE LEGEND

Ⓐ PROPOSED BRIDGE

Ⓑ EXISTING BRIDGE WITH ALTERATIONS



INTERIM SURVEY - FLOOD CONTROL

MINNESOTA RIVER AT CHASKA, MINNESOTA

PROPOSED CHASKA CREEK DIVERSION PLAN & PROFILE

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

ST. PAUL DISTRICT CORPS OF ENGINEERS

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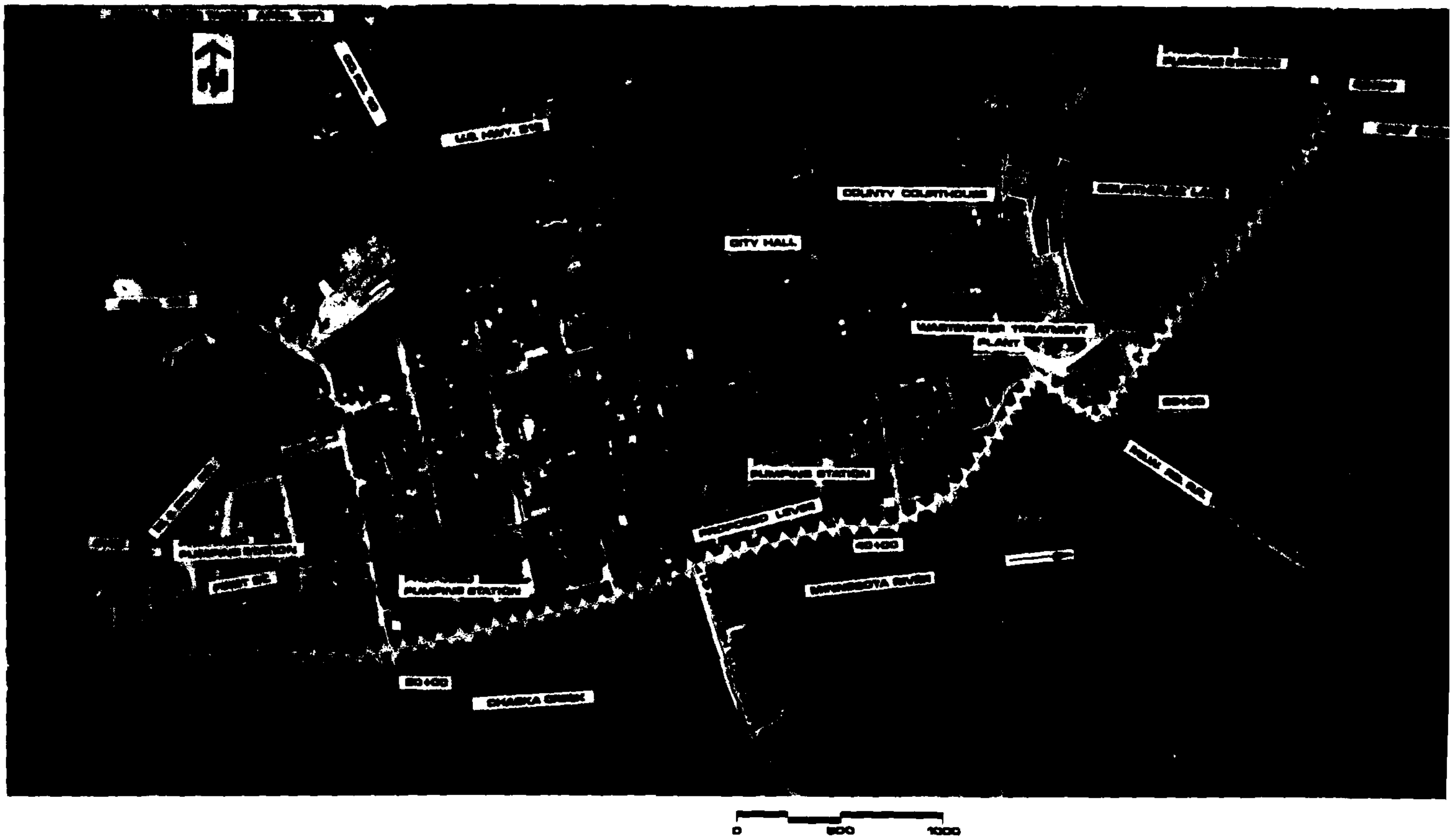
PLATE NO. 5

2

CORPS OF ENGINEERS



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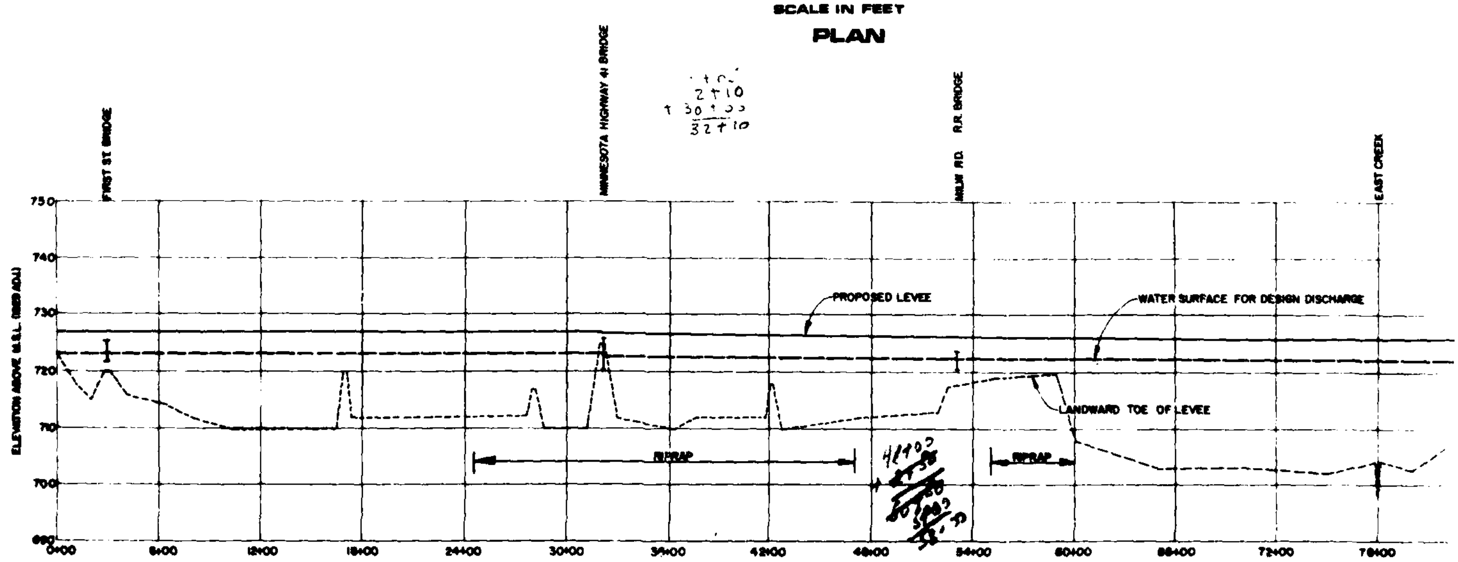
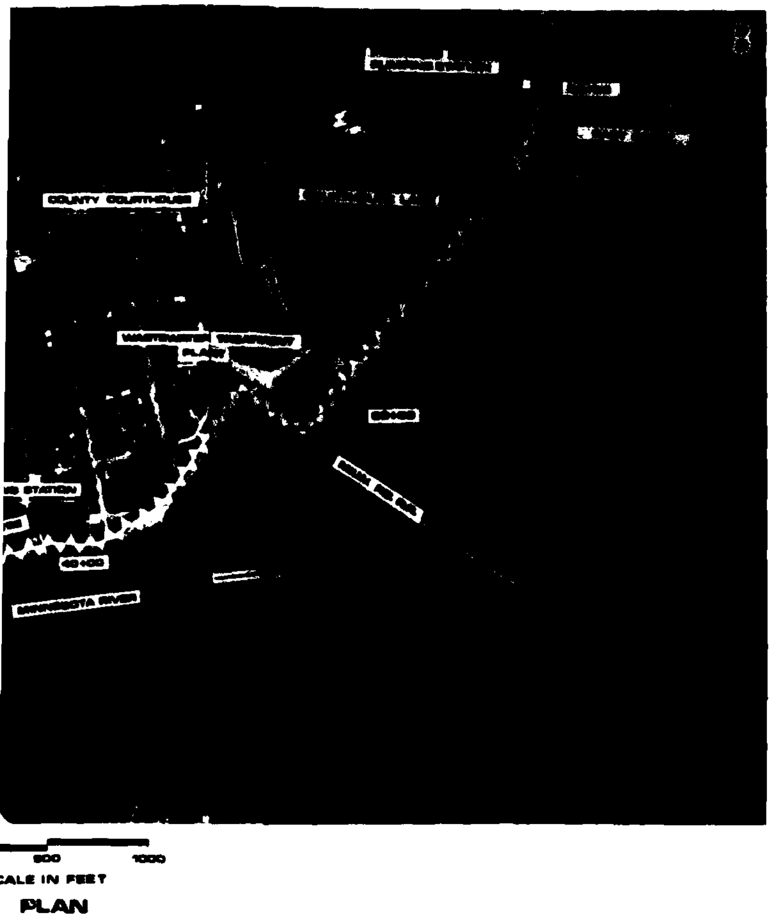
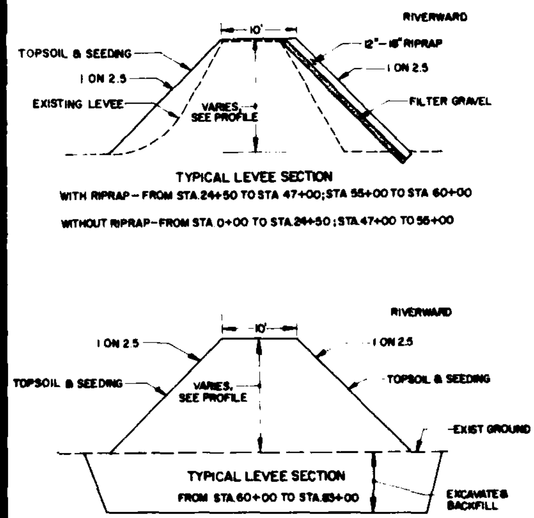


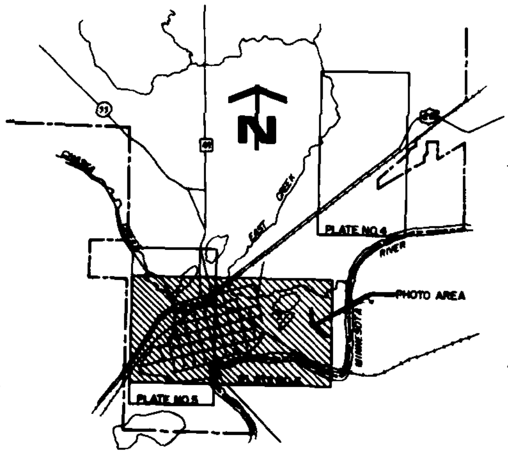
LEVEE STATIONING IN FEET
PROPOSED ALIGNMENT

PROFILE

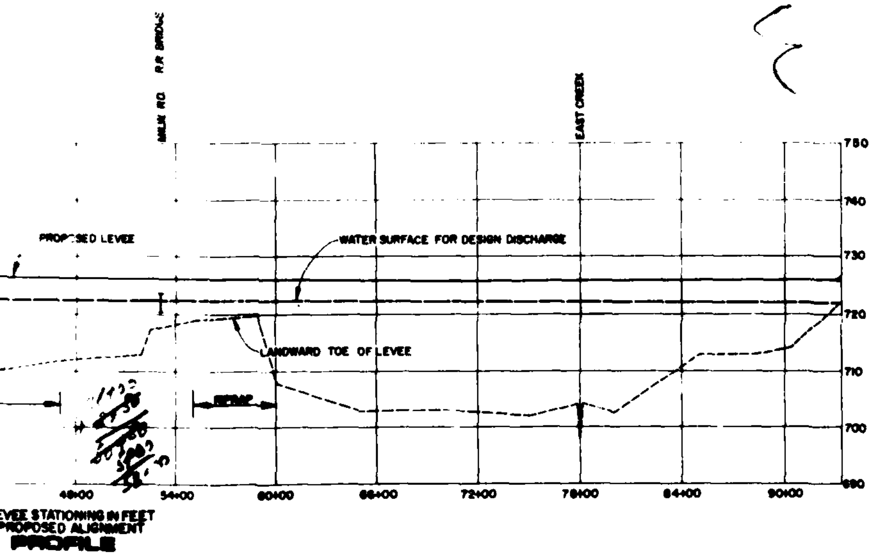
U. S. ARMY







INDEX MAP OF CHASKA, MINNESOTA



INTERIM SURVEY - FLOOD CONTROL

MINNESOTA RIVER AT CHASKA, MINNESOTA

PROPOSED LEVEE IMPROVEMENTS PLAN & PROFILE

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

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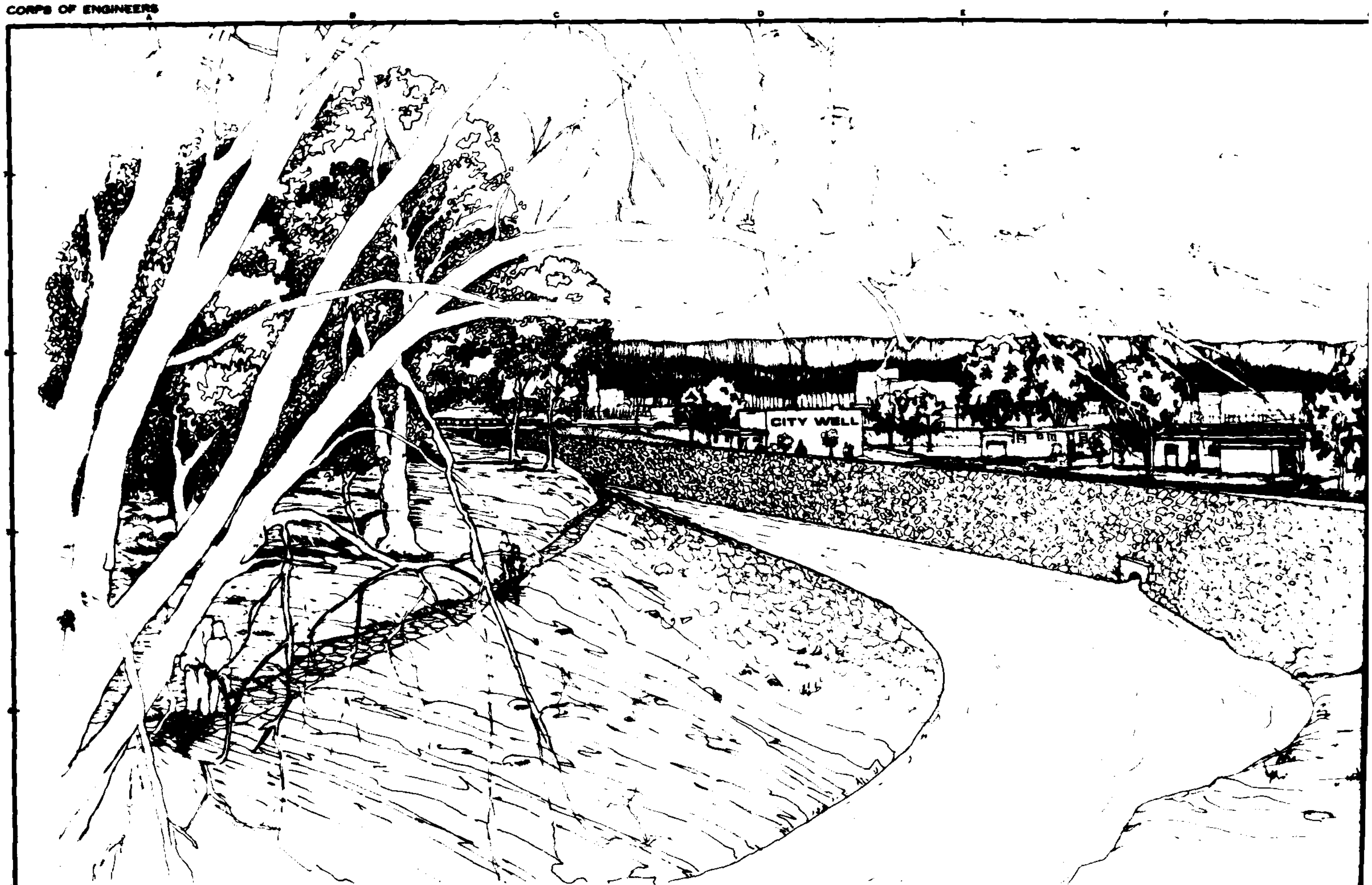
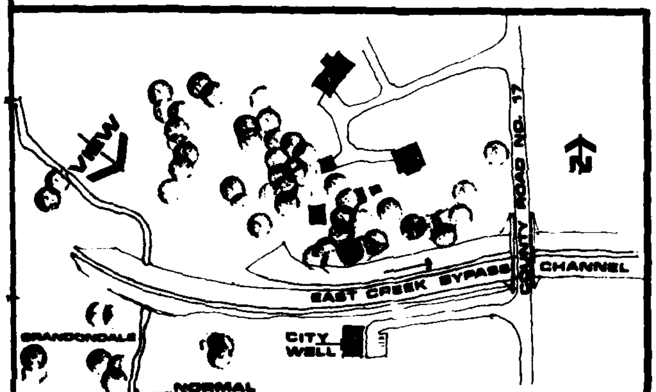
TRANSMITTED WITH REPORT DATED: AUGUST 1973

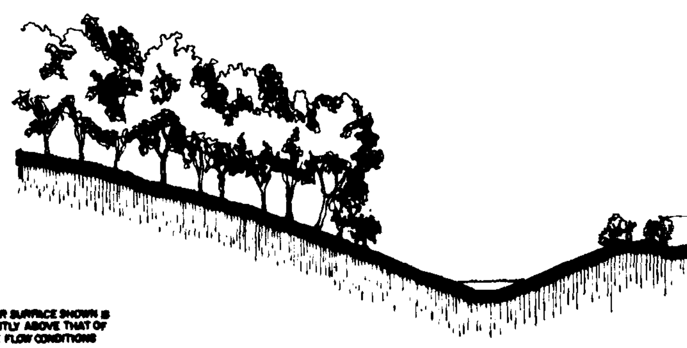
PLATE NO. 6

2





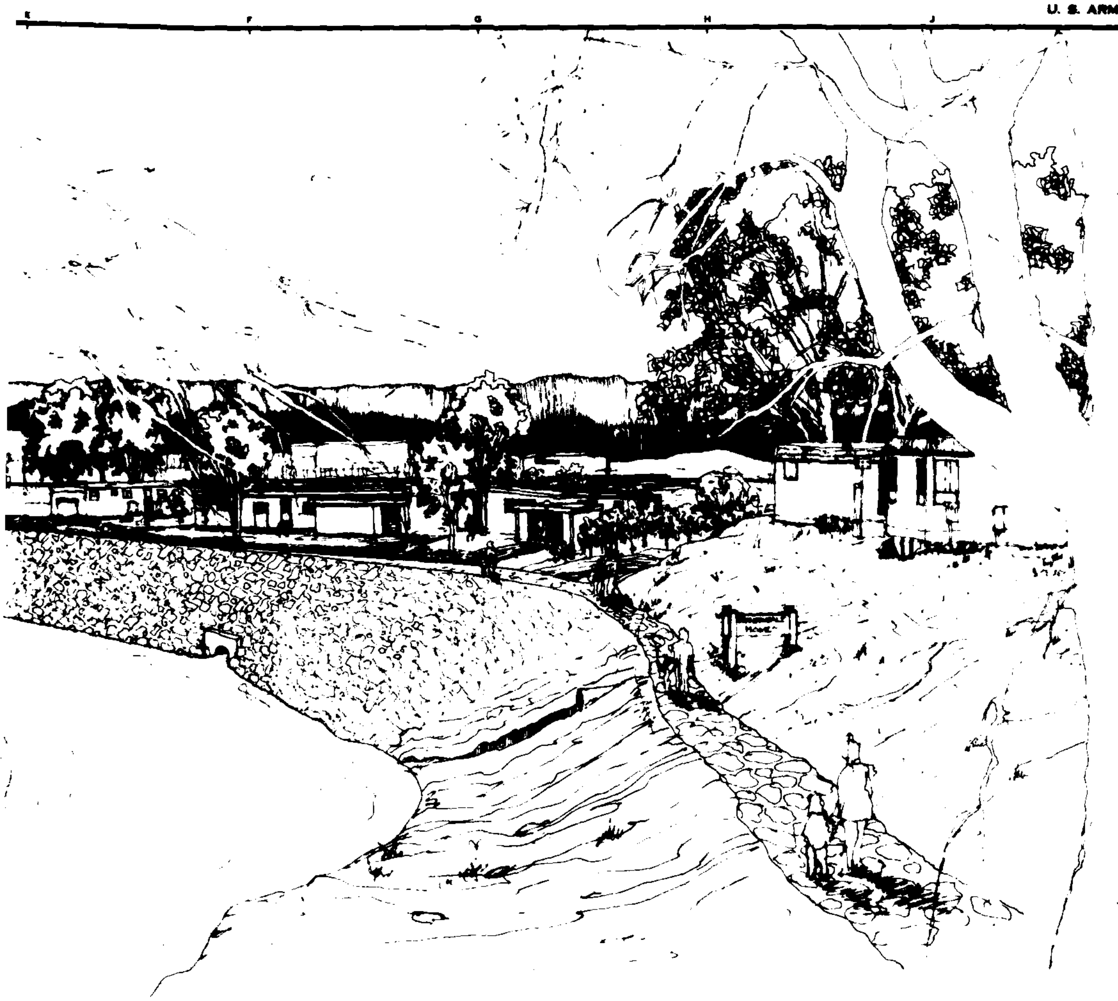
PLAN

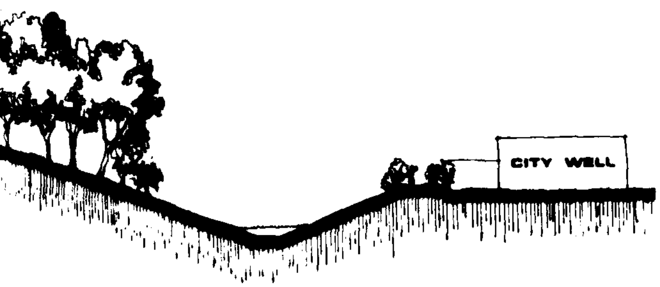


NOTE: WATER SURFACE SHOWN IS SLIGHTLY ABOVE THAT OF BASE FLOW CONDITIONS

SECTION

U. S. ARMY





SECTION

INTERIM SURVEY - FLOOD CONTROL

MINNESOTA RIVER AT
CHASKA, MINNESOTA

ENVIRONMENTAL AND
AESTHETIC CONSIDERATIONS
FOR THE
EAST CREEK FLOOD BYPASS
STRUCTURE AND CHANNEL

IN 1 SHEET | SHEET NO. 1

SCALE AS SHOWN

ST. PAUL DISTRICT CORPS OF ENGINEERS

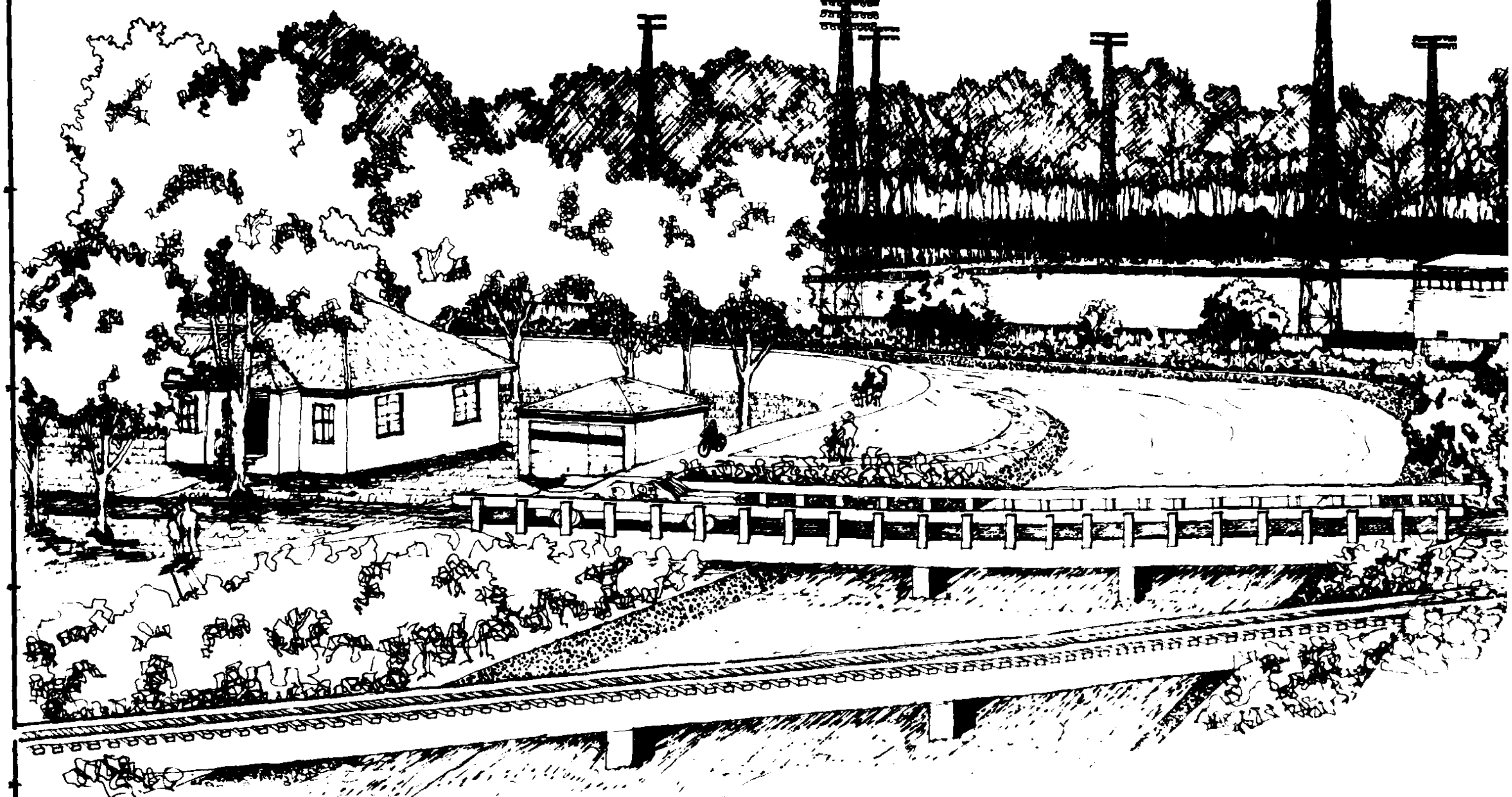
DRAWN BY
CHECKED BY: C.E.B

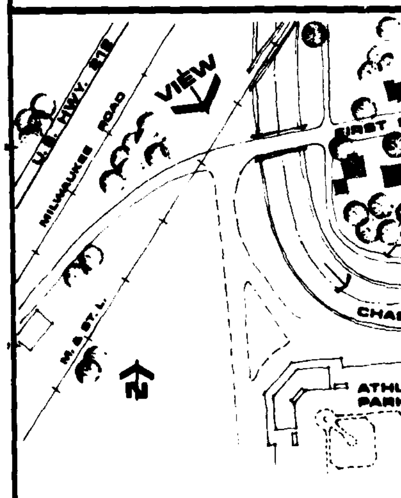
FILE NO.
M34-CH-R-7/7

TRANSMITTED WITH REPORT
DATED: AUGUST 1973

PLATE NO. 7

2





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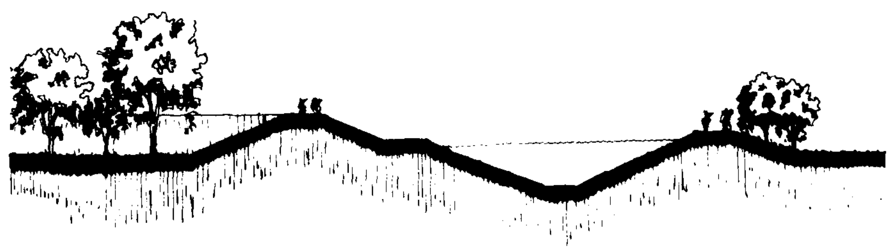
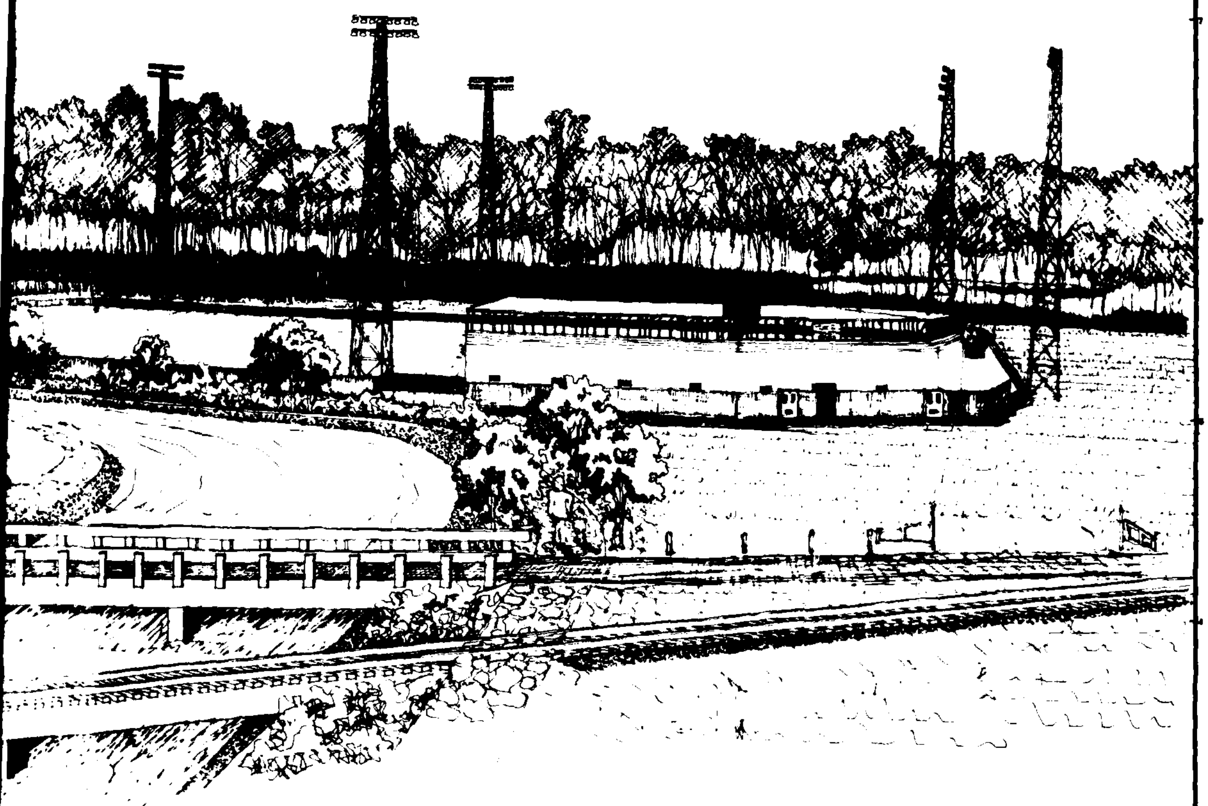


NOTE: WATER SURFACE SHOWN IS APPROXIMATELY THAT OF DESIGN FLOOD CONDITIONS

SECTION

U. S. ARMY



SECTION

INTERIM SURVEY - FLOOD CONTROL

MINNESOTA RIVER AT CHASKA, MINNESOTA

ENVIRONMENTAL AND AESTHETIC CONSIDERATIONS FOR CHASKA CREEK NEAR FIRST STREET BRIDGE

IN 1 SHEET SHEET NO. 1

SCALE AS SHOWN

ST. PAUL DISTRICT CORPS OF ENGINEERS

DRAWN BY
CHECKED BY CEB

FILE NO
M34-CH-R-7/8

TRANSMITTED WITH REPORT
DATED AUGUST 1973

PLATE NO 8

2

DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
1210 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

FEASIBILITY REPORT

FOR FLOOD CONTROL

MINNESOTA RIVER

AT CHASKA, MINNESOTA

APPENDIX A

GEOLOGY, SOILS DATA AND ANALYSIS

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APPENDIX A

GEOLOGY, SOILS DATA AND ANALYSIS

TOPOGRAPHY

1. The portion of the city of Chaska, Minn., where the proposed flood control improvements would be located is within the Minnesota River valley. The valley trends northeast and is 2.5 miles wide in this reach. The floodplain lies at approximately elevation 705, averages 1 mile in width, and is characterized by extensive marshy areas and lakes. Alluvial and bedrock terraces rise above the floodplain and form regionally prominent benches at elevations 750 and 800. Most of the developed portion of Chaska is situated between elevations 710 and 730 at the upstream limit of a terrace that trends northeast along the base of the valley wall. The river valley walls rise sharply above the floodplain and terraces to form a bluff that grades into a hummocky, poorly-drained regional highland at elevation 850 on the north side of the valley and 900 on the south side of the valley.

2. Chaska Creek emerges from the regional highland in a deep, steep-walled valley on the northwest side of Chaska and flows in a shallow channel around the western and southern edges of the city to the Minnesota River. East Creek emerges from a similar but smaller valley onto a large terrace about 1.5 miles northeast of Chaska. The creek flows southwesterly across the terrace, cuts through the northeast corner of old Chaska, and joins the Minnesota River downstream of the city. The normal flow in the two creeks is sustained by groundwater discharging from pervious materials in thick glacial till deposits that comprise the surrounding regional highlands.

GEOLOGY

3. The region surrounding the project area was glaciated extensively during the Pleistocene Epoch. The glaciers laid down thick deposits of outwash sands and unsorted tills that today form a hummocky, poorly-drained plain dotted with marshes and small lakes. The glacial drift reaches a thickness of 200 to 250 feet and rests on dolomitic limestone and sandstone of the Prairie du Chien and Jordan Formations. The large valley of the present Minnesota River was carved by the glacial River Warren, which carried large volumes of water discharging from the now-extinct glacial Lake Agassiz located in western Minnesota and eastern North Dakota. This river, the ancestor of the Minnesota River, cut deeply into bedrock and formed the terraces that are prominent today. As the flows decreased, the valley was filled to its present level with alluvial sand, silt, and soft clay.

4. The alluvial sediments under the existing levee consist primarily of fine and medium sand. Boring 73-1M located near the mid-point of the existing levee ended in the sand at a depth of 152 feet. Silt and clay are the dominant surficial materials under the proposed levee extension. Boring 73-3M located in this area penetrated 58 feet of silt and clay and ended in silty fine sand at a depth of 62 feet. Bedrock underlies the floodplain at a depth greater than 150 feet and is expected to be sandstone of the Franconia and Dresbach Formations. The broad floodplain and lower terrace levels are frequently flooded, poorly drained, and characterized by a high water table.

SUBSURFACE INVESTIGATIONS

5. In March 1973, nine borings were taken along or adjacent to the proposed levee alignment as shown on plate A-1. Boring logs are shown on plate A-2. Data from field investigations and information from borings obtained by the Minnesota Department of Highways were also utilized in this analysis.

SUBSURFACE CONDITIONS

6. The existing levee, located west of the Milwaukee Road Railroad (see plate 2 of the main report), has been constructed on a deep bed of sand. The sand deposit contains layers of silt and clay throughout the 152 feet drilled in boring 73-1M. The gradation of the sand beds varies from very fine to coarse. The existing levee consists of material varying from clay and silts to sands. Although foundation seepage was observed with floodwater near the top of the existing levee, no seepage was observed passing through the levee embankment. The importance of the layers of silt and clay interbedded in the thick sand bed and the variation in the gradation of the sand layers is covered in the paragraph on Design Considerations.

7. The levee extension northeast of the railroad would be constructed on a thick deposit of impervious material. Between the tracks and East Creek, the foundation soil consists of up to 25 feet of low strength clay (CH-OH); see boring logs 73-2M and 73-3M.

8. No borings were taken along the proposed East Creek flood bypass channel or the Chaska Creek diversion channel. Soils along the diversion channel probably consist of a mixture of silts, clays and silty sand over poorly graded sand. Excavation would probably extend into the sand near the downstream end of the diversion. The major portion of the East Creek diversion channel would probably be excavated in clays and/or silts. Excavation in the

Minnesota River floodplain may present some problems due to low strength alluvial deposits. Sand layers or pockets producing shallow artesian wells are known to exist along the river and, when the confining impervious beds are penetrated by excavating the channel, the pressure release is accompanied by sand flows. The pressure generally dissipates rather rapidly and a stable condition can be obtained. No apparent rock outcroppings exist in the proposed excavation areas.

PROJECT FEATURES

9. GENERAL

The proposed improvements at Chaska consist of a 0.9-mile diversion channel for Chaska Creek, 1.2-mile flood bypass channel for East Creek, three drop structures on each creek, eight new bridges, upgrading 1.1 miles of existing levee, constructing 0.6 mile of new levee, installing four pumping stations, a recreational trail system and general landscaping and tree planting in construction areas. The plan also includes floodplain regulation on East Creek near U.S. Highway 212, Chaska Creek upstream from the diversion channel, in ponding areas needed for interior drainage, and along the Minnesota River outside the leveed area. Plate 3 of the main report provides pertinent information on the location, limits and types of improvements being proposed. The project features are designed to provide Chaska protection against the intermediate regional flood on East Creek, Chaska Creek and the Minnesota River.

10. FLOOD BYPASS AND DIVERSION CHANNELS

Bypassing flood flows from the natural channels of East Creek and Chaska Creek is a major element in the proposed plan (see main report, plate 3). Approximately 1.2 miles of rock-lined trapezoidal flood bypass channel would be used for East Creek starting at the bluff of the Minnesota River valley and ending at the Minnesota River just east of Chaska (see main report, plate 4). The channel would pass mainly through presently undeveloped commercial or industrial zones. The use of two concrete drop structures, each about 10 feet high and 60 to 120 feet wide, would reduce design flow velocities to the point where lining the channel with rock would prevent streambank erosion. Also, a sheet-pile drop structure would be required on the East Creek bypass channel at the Minnesota River to control erosion. An earthen embankment 8 to 20 feet high and 700 feet long would be constructed across the natural East Creek channel to direct flood flows into the diversion channel. Normal low flows on East Creek would be maintained in the natural channel by using a gated conduit under the diversion embankment.

11. The 0.9 mile Chaska Creek diversion channel would start about 500 feet upstream from U.S. Highway 212 and pass through a sparsely developed industrial zone along the western side of Chaska to the Minnesota River floodplain (see main report, plate 5). Approximately 0.1 mile of concrete-lined channel would be required upstream from U.S. Highway 212. The remaining 0.8 mile of channel would have a trapezoidal shape and a rock lining. Three drop structures would be required to control channel velocities and prevent erosion. A recreation trail along the channel would provide a tie between the Minnesota River Valley Trail system and stream corridor open space areas being acquired by Chaska.

12. The proposed channels would require the construction of two new city street bridges, two county highway bridges;one U.S. highway bridge, one State highway bridge and three railroad bridges. Modification of some sewer, water, and telephone lines would also be required. As currently proposed, the relocation of seven houses, six mobile homes and one business would be necessary.

13. LEVEES AND PUMPING STATIONS

The proposed plan includes a 20-to 25-foot-high, 9,250-foot-long levee and four pumping stations to protect Chaska from the Minnesota River (see main report, plates 3 and 6). Approximately 6,000 feet of existing emergency levee would be upgraded to permanent levee standards by flattening the side slopes, raising the levee about 1 foot, and providing riprap slope protection in areas where erosion would otherwise occur. The remaining 3,250 feet of levee would be placed on an alignment just east of Courthouse Lake connecting the existing emergency levee to high ground.

14. A relief well system along the toe of 5,000 feet of levee would reduce uplift pressures and control seepage. About 5,000 feet of stormwater interceptor sewers along the levee toe would carry seepage and runoff to the gated gravity outlets or the pumping stations during high stages on the Minnesota River. The Chaska Creek, Elm Street, Maple Street and East Creek pump stations would have 23,800 gpm, 56,600 gpm, 59,200 gpm, and 84,000 gpm capacity, respectively, for discharging interior runoff during high river stages. A temporary ponding area would have a design capacity of 120 acre-feet. A control structure between the natural East Creek channel and Courthouse Lake would be provided to reduce the frequency of ponding in the lake and to maintain the trout fishery. A stop-log closure structure at the Milwaukee Road Railroad crossing, low sandbag closures at the Highway 41 and First Street levee crossings, and a seepage barrier at the Minneapolis and St. Louis

Railroad crossing would be required to complete the flood barrier. A permanent cutoff wall of steel sheet-piling would be driven below the railroad crossings and the ballast would be impregnated with hot asphalt to reduce seepage through the underground foundations and pervious ballast. In addition, alterations to existing sanitary and water supply facilities and utility lines would be provided.

DESIGN CONSIDERATIONS

15. SLOPE STABILITY AND SETTLEMENT

Slope stability and settlement analyses were not performed for this report. Upstream of the railroad the relatively dense pervious foundation overlain by a thin semipervious layer should preclude stability problems. This would be verified in postauthorization studies. It is proposed that the weak foundation materials in the marshy area downstream of the railroad (station 64+00 to station 83+00) would be excavated to an average depth of 25 feet. Postauthorization studies would include undisturbed sampling, strength and consolidation tests to determine the supportive capability of the foundation material in this reach. Partial removal, use of berms, and combinations of these measures would be investigated during postauthorization studies. Settlement is not considered a serious problem, but would be analyzed fully in postauthorization studies.

16. SEEPAGE AND UPLIFT

The boring logs indicate that seepage would be a problem for that portion of the levee located west of the Milwaukee Road Railroad tracks. During the 1969 flood, considerable underseepage was observed landward of the levee in this area. Some heaving of bituminous paved areas was also observed. Piping in the form of sand boils was not observed. Records indicate that approximately 20,000 gpm (gallons per minute) including the sanitary wastewater flows from the Chaska treatment plant were being pumped during the peak of the 1969 flood.

17. For this report two methods were used to determine the magnitude and a solution to the seepage problem. Using soil data available or assumed, the quantity of seepage and relief wells required was computed. As shown on borings 73-1M, 73-6M, and 73-8M, the area has a deep pervious foundation overlain by a very thin semipervious layer containing several thin beds of clay and silt. It was assumed that a landward blanket does not exist and large quantities of seepage must be controlled to prevent damage. It was further assumed that uncontrolled seepage would not exceed 6 gpm per foot of levee. A uniform pervious foundation was assumed, and a coefficient of permeability $k = 0.25$ was selected based on experience with similar foundations in

the Mankato, Minn., area. Results indicated seepage would be 175,000 gpm and would require approximately 59 relief wells spaced at 70 and 90 feet on center along the levee toe. Results of the above analysis greatly exceeded the 20,000 gpm recorded for the 1969 flood. However, based on the 1969 recorded data and computation adjustments to reflect maximum design head conditions and seepage from the relief wells, a total seepage flow of approximately 50,000 gpm is indicated.

18. Several factors account for the difference in the two estimates. Our first analysis assumed no riverward blanket, but west of Pine Street and east of Ash Street is a considerable blanket. The logs indicate that there is probably a continuous landside blanket of over 4 feet in thickness, the upper sands are much less pervious than assumed, and an effective thin impervious layer exists at a depth of about 30 feet below the ground surface. Accordingly, a system of 59 relief wells together with a pumping capacity of 50,000 gpm was used for the seepage control measures in this report. Extensive subsurface investigation and testing would be accomplished during the postauthorization studies to assure that an effective seepage control system is provided.

19. SLOPE PROTECTION

The landward slope and top of levee and slopes of ditches and ramps would be covered with 4 inches of topsoil and seeded. Riprap protection would be provided at outfalls and along levee reaches where erosion otherwise would occur. Also, riprap protection would be provided on the channel bottom and side slopes for the Chaska Creek diversion and East Creek flood bypass channels. Typical levee and channel riprap sections are shown on plates 4, 5, and 6 of the main report.

20. DISPOSAL

Excavated material from beneath the levee extension reach would be used in landward or riverward berms wherever space permits. Suitable material excavated from the diversion and bypass channels would be utilized in the proposed levee and East Creek bypass structure embankments. Excess material from channel excavations would be disposed of in overburden areas as part of the expansion of recreational areas in the vicinity of Courthouse Lake. Other potential disposal areas, if required, include fill areas in the Jonathan development and proposed new Highway 41 embankment area. However, final selection of suitable disposal areas would be determined during advanced planning, if needed.

SOURCES OF CONSTRUCTION MATERIALS

21. RIPRAP AND BEDDING

Riprap and bedding of adequate quality could be obtained from limestone quarries, developed in the Prairie du Chien Formation, located on the south side of the Minnesota River valley within 10 miles of Chaska.

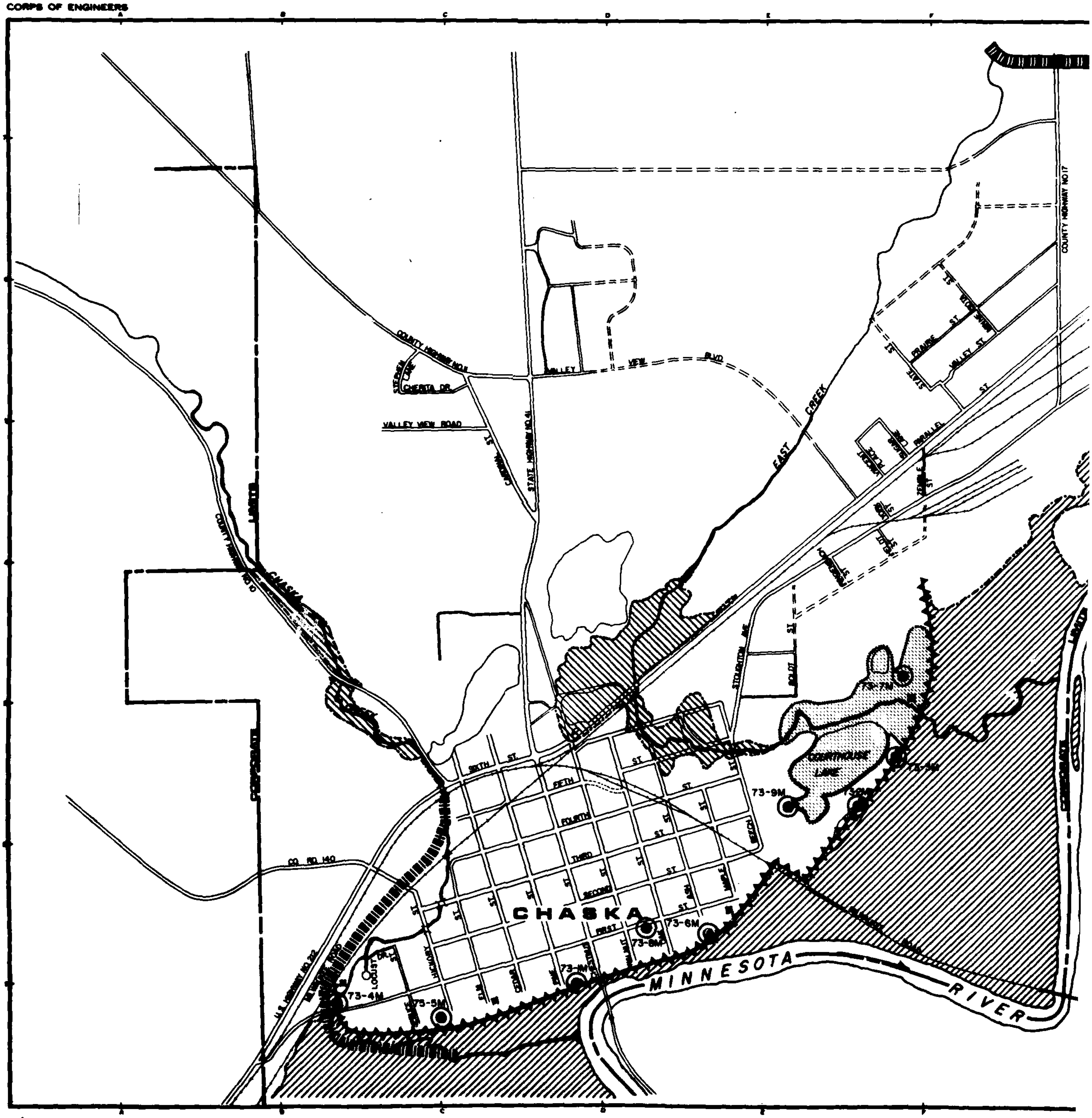
22. CONCRETE AGGREGATE

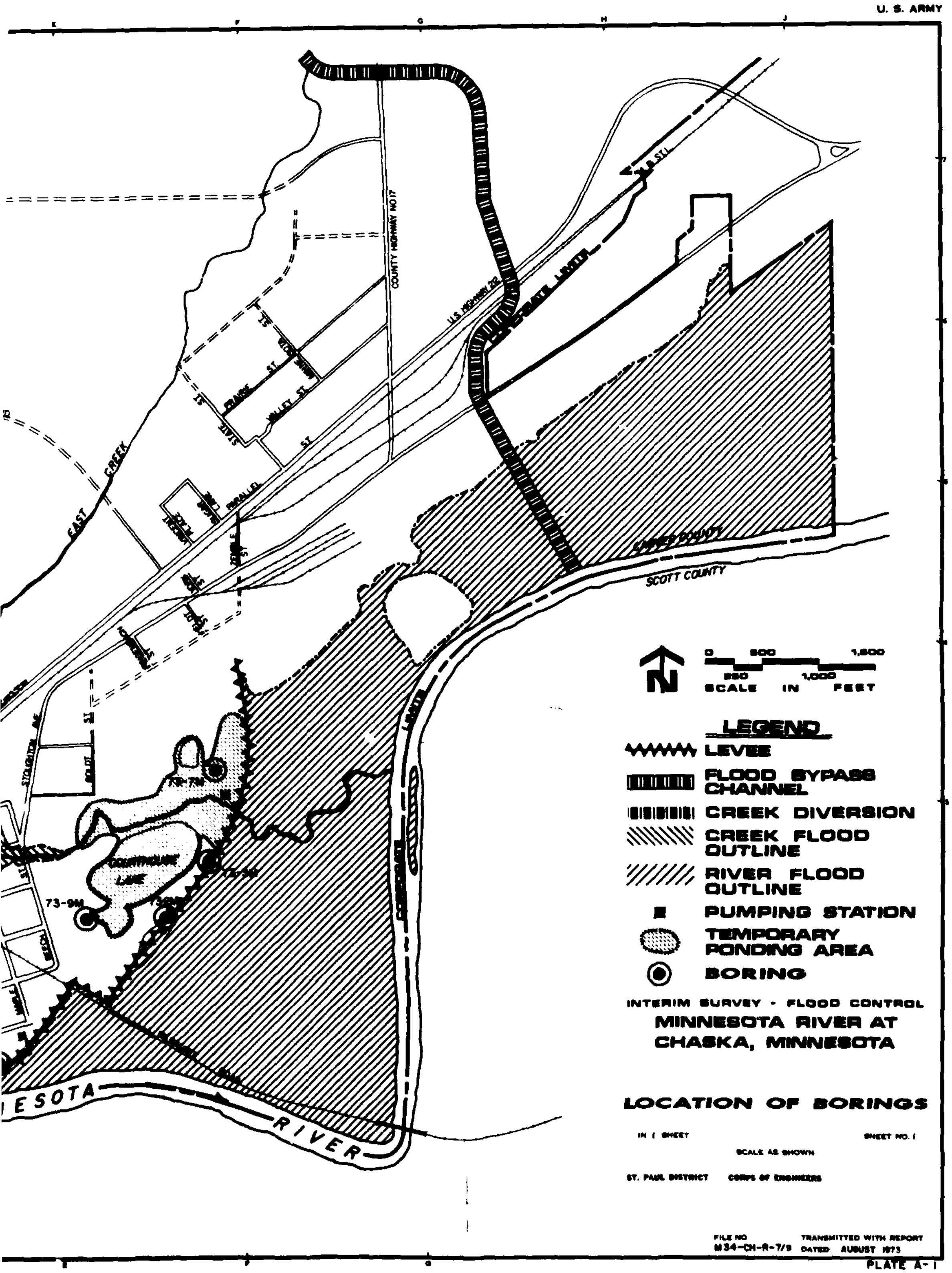
Concrete aggregate of adequate quality could be obtained from continuously operating natural aggregate and crushed rock sources in the Minneapolis-St. Paul, Minn., metropolitan area. The distance from the project to reliable sources in this area would be 25 to 50 miles. Closer sources located within 10 miles of Chaska exist but produce concrete aggregate on an intermittent basis. Although the closer sources have not been tested or used for Corps of Engineers projects, information obtained from the Minnesota Department of Highways indicates this material would be adequate as a concrete aggregate.

23. LEVEE FILL

Levee fill would consist of impervious glacial till obtained from the diversion and bypass channel excavations. A plentiful supply of impervious glacial till deposits is available from the surrounding uplands in the event sufficient quantities are not obtainable from channel excavations.

CORPS OF ENGINEERS




U. S. ARMY
COUNTY HIGHWAY NO 17
U.S. HIGHWAY 212
EAST CREEK
CARVER COUNTY
SCOTT COUNTY
0
500
1,500
250
1,000
SCALE IN FEET
LEGEND
LEVEE
FLOOD BYPASS CHANNEL
CREEK DIVERSION
CREEK FLOOD OUTLINE
RIVER FLOOD OUTLINE
PUMPING STATION
TEMPORARY PONDING AREA
BORING
73-7M
73-9M
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT
CHASKA, MINNESOTA
LOCATION OF BORINGS
IN 1 SHEET
SHEET NO. 1
SCALE AS SHOWN
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO
M34-CH-R-7/9
TRANSMITTED WITH REPORT
DATED AUGUST 1973
RIVER
PLATE A-1

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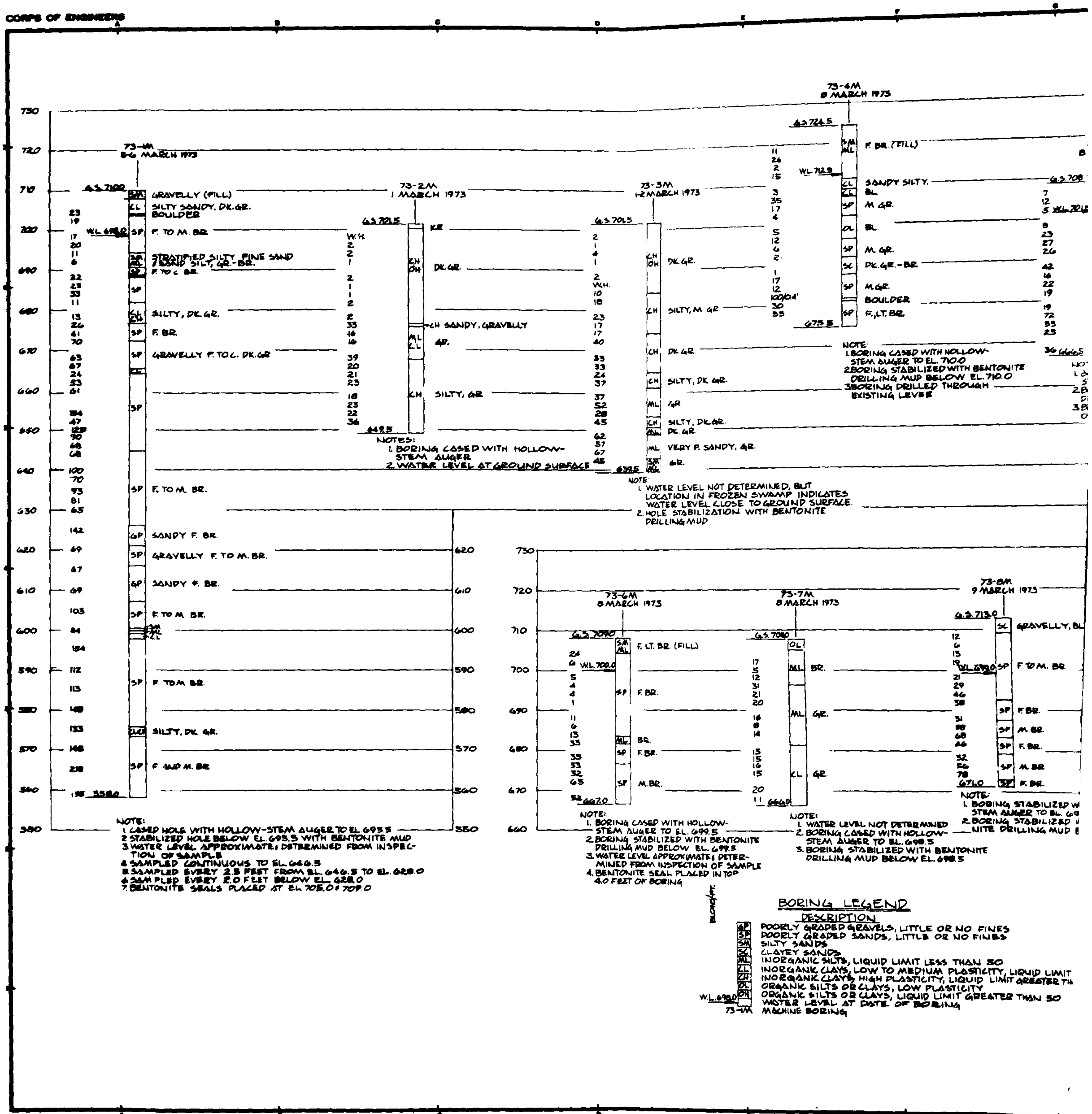
CORPS OF ENGINEERS



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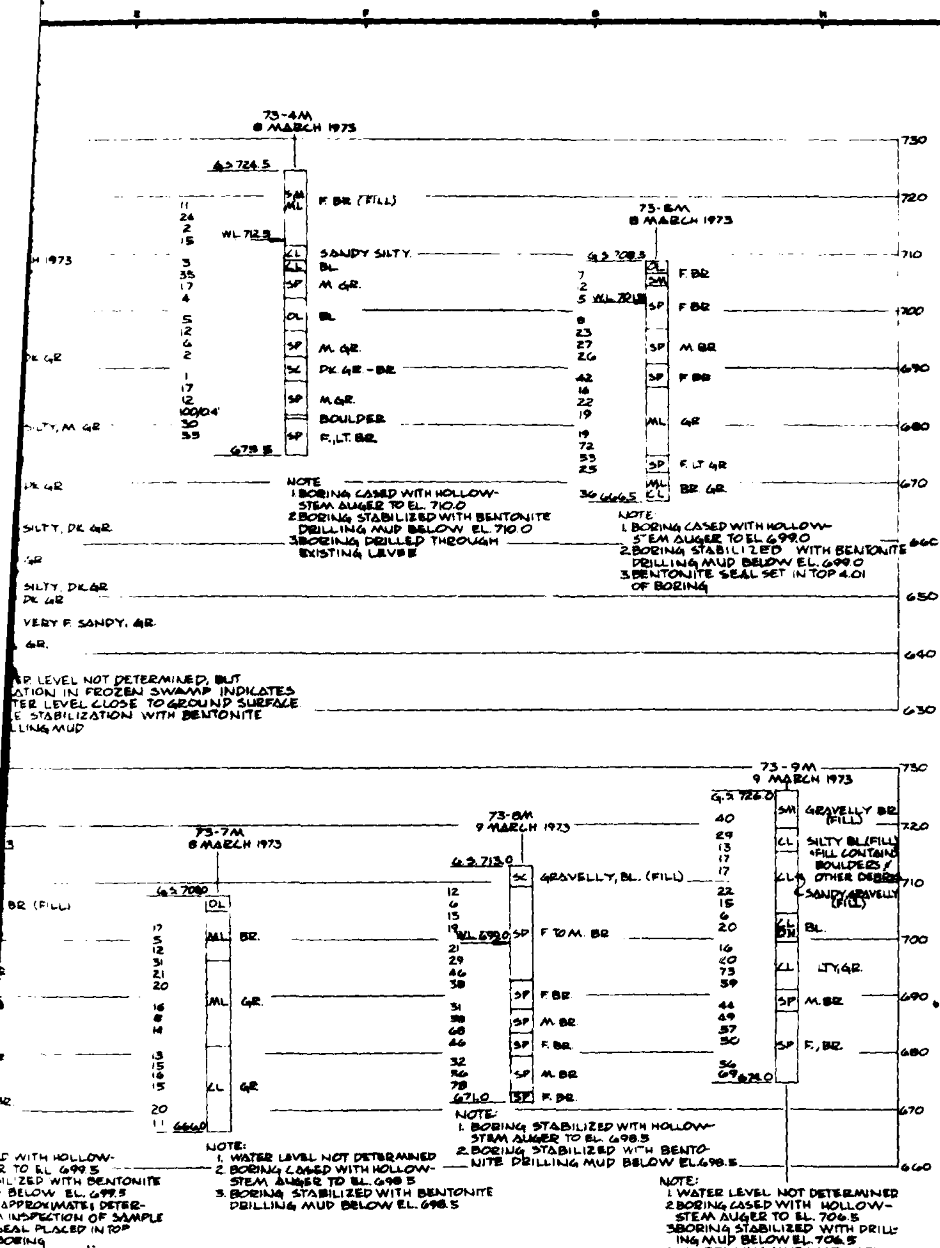

BORING NOTES

1. GENERAL: THE LEGEND PRESENTS ONLY THE BASIC SOILS: TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING LOG.
2. FIELD CLASSIFICATION SHOWN FOR ALL SOILS.
3. DUAL CLASSIFICATION: WHERE SOIL IS CONSIDERED TO BE ON THE BORDER LINE OF TWO OR MORE GROUPS A DOUBLE SYMBOL IS USED i.e.- (GP-GM) OR (CL-ML)
4. BLOW COUNT: BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING LOGS AND ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12 INCHES. SAMPLER SIZE AND PENETRATION EFFORT ARE NOTED ON THE LOGS. ALL UNMARKED BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST, USING A 1⅜" x 2" SAMPLER, 140 LB. HAMMER AND 30" DROP.
5. PARTICLE SIZE: FINE, MEDIUM AND COARSE SANDS ARE DESIGNATED BY THE LETTERS F, M AND C TO THE RIGHT OF THE BORING LOG.
6. SOIL COLOR IS SHOWN AS LT. (LIGHT), DK. (DARK), BR. (BROWN), GR. (GRAY), AND BL. (BLACK) TO THE RIGHT OF BORING LOG.
7. FOR BORING LOCATIONS, SEE PLATE A-2.

BORING LEGEND

DESCRIPTION

GP	POORLY GRADED GRAVELS, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, LITTLE OR NO FINES
SM	SILTY SANDS
SC	CLAYEY SANDS
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
CL	INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY, LIQUID LIMIT LESS THAN 50
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY
OH	ORGANIC SILTS OR CLAYS, LIQUID LIMIT GREATER THAN 50
W.L. 698.0	WATER LEVEL AT DATE OF BORING
73-1M	MACHINE BORING

INTERIM SURVEY MINNESOTA RIVER AT CHASKA, MINNESOTA — FLOOD CONTROL

CHASKA BORING LOGS

IN 1 SHEET — SHEET NO. 1

SCALE AS SHOWN

ST. PAUL DISTRICT — CORPS OF ENGINEERS

FILE NO. M34-CH-R-7/10 — TRANSMITTED WITH REPORT DATED: AUGUST 1973

PLATE NO. A-2

DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
1210 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

FEASIBILITY REPORT

FOR FLOOD CONTROL

MINNESOTA RIVER

AT CHASKA, MINNESOTA

APPENDIX B

HYDROLOGY, HYDRAULICS AND INTERIOR DRAINAGE

TABLE OF CONTENTS

APPENDIX B

HYDROLOGY, HYDRAULICS AND INTERIOR DRAINAGE

CLIMATOLOGY

1. GENERAL

The climate of Chaska and its vicinity is moderate, characterized by wide variations in temperature, normally sufficient rainfall for crops, and moderate snowfall. The Chaska weather observation station of the National Weather Service was established in May 1925 and has been in operation since that time. The station is located 1 mile northeast of Chaska at the American Crystal Sugar Company plant.

2. TEMPERATURE

The mean annual temperature for Chaska is about 45° F, with the mean monthly temperature varying from about 74° F in July to 14° F in January. The most extreme temperatures have been recorded as a high of 109° F on 14 July 1936 and a low of -43° F on 30 January 1951. The average number of days between freezing temperatures is 153, based on a 24-year average.

3. PRECIPITATION

The normal annual precipitation in Chaska is 27.12 inches. Annual precipitation has ranged from a maximum of 39.94 inches in 1965 to a minimum of 16.44 inches in 1936. The normal monthly precipitation varies from a maximum of 4.88 inches in June to a minimum of 0.54 inch in January. The maximum rainfall recorded at Chaska for a 24-hour period is 4.96 inches, occurring on 8 July 1955. Snowfall records for Minneapolis, Minn., which is located approximately 19 miles northeast of Chaska, indicate an average annual snowfall of about 44 inches. The snowfall represents approximately 16 percent of the yearly precipitation.

4. NOTABLE STORMS

Only one major storm has been recorded for the Chaska vicinity. It centered in Minneapolis. The storm duration was from 24-28 July 1892, during which a maximum depth of 8.4 inches of rainfall occurred in 60 hours. Of this amount, 6.35 inches fell within 12 hours. The maximum rainfall recorded at Chaska for a 24-hour period is 4.96 inches, occurring on 8 July 1955.

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FEASIBILITY REPORT FOR FLOOD CONTROL, MINNESOTA RIVER AT CHASKA--ETC(U)
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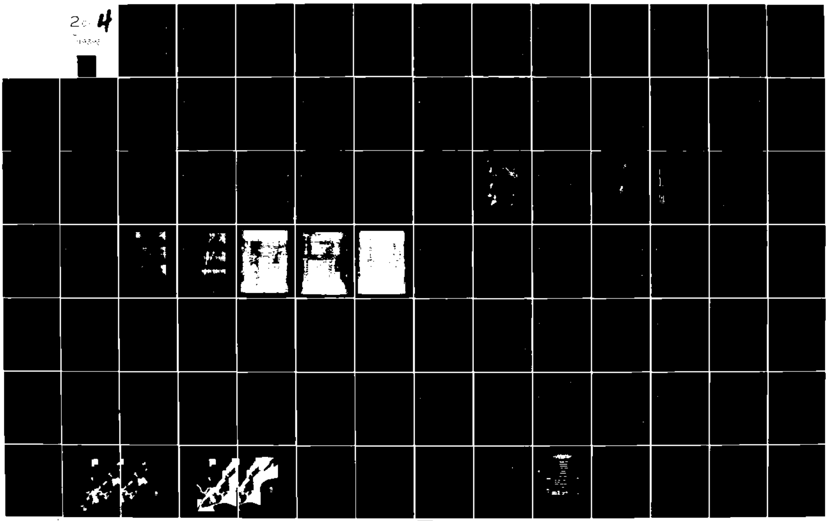


STREAMFLOW, RUNOFF AND FLOODS

5. STREAMFLOW RECORDS

A river gage has been located on the Minnesota River at Chaska since 31 July 1951. The gage was located on a bridge on State Highway 41 until 13 April 1961 when it was moved about 100 feet downstream to a new bridge on State-Aid Road 30. The gage has been at that location since that date. The zero of the gage at both locations has been at elevation 688.0 feet (1929 adjustment). The gage is located 29.6 miles above the mouth of the Minnesota River. Daily gage heights were obtained during spring and summer months from August 1951 through 1954. Since that time, daily observations have been made only during periods of high stages and during some spring months. Occasional fragmentary observations have been made at other times.

6. The U.S. Geological Survey has maintained a stream gaging station on the Minnesota River several miles upstream from Chaska since September 1934. Originally located at river mile 36.0 and called "near Carver", the gaging station was moved upstream to river mile 39.4 on 1 October 1966 and named "near Jordan". The gage zero is 690.0 feet above mean sea level (1929 adj) at both sites. Drainage areas (approximately 16,200 square miles) and discharges are nearly the same at both sites. The present gage site is 9.8 river miles upstream from the bridge across the Minnesota River at Chaska. Two major creeks discharge into the Minnesota River between the Jordan gage and Chaska, namely, Sand Creek from the south and Carver Creek from the north. The drainage area of the Minnesota River at Chaska as shown on plate 1 of the main report is approximately 16,600 square miles. The largest discharge of record at the Jordan or Carver gaging stations was 117,000 cfs (cubic feet per second) on 11 April 1965 and the maximum gage height was 34.37 feet on 12 April 1965 (effected by backwater from the Mississippi River). The minimum flow of record was 79 cfs on 17 November 1955. Average discharge for 35 years is 3,306 cfs.

7. There are no gage height records on either Chaska Creek or East Creek at Chaska. A few miscellaneous discharge measurements of streamflow have been made by the U.S. Geological Survey on Chaska and East Creeks, both at U.S. Highway 212.

8. RUNOFF CHARACTERISTICS

Because of the large difference in drainage areas, the runoff characteristics of the Minnesota River are quite different from those of the creeks. The average discharge for 35 years of 3,306 cfs on the Minnesota River near Jordan amounts to an average depth of runoff of 2.77 inches per year from the total drainage area. This amounts to 2,395,000 acre-feet per year. Annual runoff at this station has varied from a minimum of 499,000 acre-feet in the water year 1940 to a maximum of 6,985,000 acre-feet in the water year 1969. During most

years, streamflow reaches a maximum in late March or April following the spring snowmelt. During some years heavy widespread rainstorms cause additional rises in streamflow, occasionally reaching higher peaks in May or June than the snowmelt runoff peaks. The streamflow generally recedes slowly during the summer months, but with occasional rises following summer storms. The streamflow continues a slow but steady recession during fall months, reaching a minimum discharge usually in February. Monthly flows have varied from a minimum of 6,800 acre-feet in January 1940 to a maximum of 2,869,000 acre-feet in April 1969. Floods rise and fall rather slowly on the Minnesota River and often rise for 2 weeks or more before reaching the peak. The recession is usually slower than the rise with occasional secondary rises before receding to the usual seasonal flows.

9. Flows in Chaska Creek and East Creek are small during most of the year. There is normally some rise in flow during and immediately after the spring snowmelt, usually in March. Spring rains may prolong the period of high flows. Intense summer rainstorms bring a fast rise in flow, but the high flow may be of short duration, from a few hours to a few days. The lakes and swamps may sustain a continuous flow in the late spring and early summer. By early summer, the infiltration capacity is usually high, so considerable rainfall is required to increase the streamflow.

10. EFFECT OF LAKE STORAGE

Flows on the Minnesota River are affected by storage in Big Stone Lake, which is the source of the Minnesota River (dam at river mile 329.7), and by Lac qui Parle Lake and Dam (dam at river mile 288.0). Another dam is under construction across the Minnesota River at U.S. Highway 75 near Odessa, Minn. (at river mile 317.3). These structures have only slight effect on the flows at Chaska (river mile 29.6). Small dams on tributaries have negligible effect on the flows of the Minnesota River. Chaska Creek has no dams or lakes but there is a small lake on a tributary. Some marshland is located along the streams in the upper portion of the basin. In the East Creek basin, Lake Bavaria and Hazeltine Lake control runoff from areas of 1.18 square miles and 0.83 square mile, respectively. Storage at Lake Grace Dam, constructed in 1968, may reduce the peak of floods of small volumes in the lower portion of East Creek. Lake Grace Dam has a maximum height of about 25 feet. The location of these lakes is shown on plate B-1. Marshland in portions of the basin may reduce the high flows on East Creek.

11. FLOOD CHARACTERISTICS

Floods on the Minnesota River at Chaska rise and recede rather slowly, because of the large drainage area. The period of rise of large floods varies from about 8 to 20 days while spring floods may recede for several weeks, with only minor rises during the general recession. Floods have remained above the point of zero damages as long as 16 days.

The four largest floods during the 36 years of U.S. Geological Survey records near Carver or Jordan all peaked in April, following the spring snowmelt. Some of these floods were increased by spring rains. Smaller peaks have occurred during summer and early fall seasons. Almost every year there is a substantial rise in the river stage in March or April, following the spring snowmelt. With the long and slow recession from major floods it is difficult to define the total volume of the floods. The total discharge for a period of 40 consecutive days, from the beginning of the first substantial rise in flow, amounted to 3.61 inches of runoff on the total drainage area during the 1965 flood and 3.64 inches during the 1969 flood. During most of the floods of record the maximum stage at the Carver gaging station occurred 1 or 2 days after the maximum discharge because of backwater from the Mississippi River. Snow and ice in the river channel at the time of the spring snowmelt may increase stages during the rising period of snowmelt runoff. However, records at the Jordan (or Carver) gaging station indicate that any ice effect at the time of the maximum spring stage or discharge is rare. Ice jams have seldom affected maximum stages of the Minnesota River at Chaska.

12. Floods on the two creeks are of short duration and may remain at overbank stage for only a few hours. Flood flows may result from rapid snowmelt, accompanied by rainfall, or from very intense rainstorms, usually of short duration, during summer months. The stages of floods in late winter or early spring months may be increased substantially by snow or ice within the channels or by ice jams. Flood stages are not likely to occur during the months of October through mid-February.

13. FLOODS OF RECORD

Floods on the Minnesota River during the 36 years of record at the Jordan (Carver) U.S. Geological Survey gaging station are listed in table B-1. Included are all floods exceeding 37,000 cfs at the stream gaging station. This discharge corresponds approximately to a gage height of 25 feet on the Chaska gage, which is the point of zero damage. However, the stage at Chaska can vary, depending on the amount of backwater from the Mississippi River. All stages on the Carver gage and those since 1966 on the Jordan gage are maximum stages from recording gages, while other stages listed are the highest observed on manual gages.

688
34
722.35

29.10
688
617

Table B-1 - Floods of record, Minnesota River in the vicinity of Chaska, Minn.(1)

Date of flood crest(2)		Gage height (feet) Chaska(3)	Carver(4)	Jordan(5)	Discharge (cfs)	Days above 37,000 cfs(6)
11 April	1965	34.25	34.37(7)	35.16	117,000	15
14 April	1969	32.35	32.16	32.85	84,600	16
11 April	1951	722-35	28.00	28.62	64,100	11
16 April	1952	29.10	28.31	28.88	60,600	13
26 June	1957	25.30	25.82(7)	26.92	40,800	3
4 April	1962	24.17	25.12(7)	26.32	39,700	3
24 October	1968	24.40	25.20	26.90	37,600	1

(1) Includes floods from September 1934 through September 1970.

(2) Date of peak discharge at Carver or Jordan gaging station. Highest gage heights usually occurred 1 day later than maximum discharge.

(3) Gage on Highway 41 bridge at river mile 29.6. Zero is 688.0 feet, mean sea level (1929 adj).

(4) Former U.S. Geological Survey gage at river mile 36.0. Zero is 690 feet, mean sea level (1929 adj).

(5) Present U.S. Geological Survey gage at river mile 39.4. Zero is 690 feet, mean sea level (1929 adj).

(6) Corresponds approximately to point of zero damages at Chaska, depending on backwater effect.

(7) Stage affected by backwater from Mississippi River. Maximum stage occurred 1 or 2 days later than maximum discharge.

NOTE: Point of zero damage at Chaska is approximately 25 feet on Chaska gage.

14. The largest flood known on the Minnesota River at Chaska was that of April 1965. The previous winter, from mid-November, was generally colder than normal and frost penetration was deep. Snowfall was about normal through January but was well above normal in February. Thawing temperatures and rain early in March melted some snow but colder temperatures later formed a layer of ice that later increased the runoff. Heavy snowfall covered the basin on 17 and 18 March, with 14 inches of new snowfall at New Ulm. Additional snowfall occurred later in March. Temperatures were well below normal in most of March. At the end of March the water equivalent of the snow cover was about 6 inches on the lower part of the Minnesota River basin. Thawing weather started about the first of April with temperatures becoming progressively warmer. From 1 to 2 inches of rainfall occurred on 3 to 6 April, adding to the snowmelt runoff. Streamflow of the Minnesota River at the Carver gaging station increased starting about 1 April and reached a peak discharge of 117,000 cfs on 11 April. The maximum stage at the Carver gaging station was 34.37 feet on 12 April (with backwater from the Mississippi River). The highest daily reading on the Chaska gage was 34.25 feet on 13 April.

15. The flood of April 1969 was the second largest in the period of record on the Minnesota River in the vicinity of Chaska. The flood was preceded by a wet fall, with more than twice the normal precipitation in September and October. This rainfall resulted in a record fall flood from Mankato, Minn., to the mouth of the Minnesota River in the latter part of October. Frequent and heavy snowfalls in December and January caused an unusually high depth of snow on the basin. Snowfall during February and March was below normal, but temperatures remained cold until mid-March. Streamflow remained at more than twice the normal throughout the winter. Warmer temperatures caused some snowmelt after the middle of March, until a cold spell prevented melting the latter part of March. There was little precipitation during this period or in April. Warm temperatures early in April melted all remaining snow. After the first few days in April the streamflow increased rapidly to its peak flow. At the Jordan gaging station the maximum discharge was 84,600 cfs on 14 April and the maximum gage height was 32.85 feet on the same date. At Chaska the maximum stage observed was 32.35 on 15 April. Upstream from New Ulm, this flood was higher than the 1965 flood on the Minnesota River.

16. Smaller floods have occurred on the Minnesota River at Chaska in April 1951, April 1952, June 1957, April 1962, and October 1968. These are listed in table B-1. Of the seven floods listed in table B-1, five were caused by snowmelt, with or without additional rainfall, and only two were caused by rainfall alone. At Mankato, 77 river miles upstream from Chaska, a flood occurred in 1881, which was reported to have been 0.8 foot higher than the 1965 flood and was the highest known there. Major floods occurred at Mankato in 1903, 1908, and 1919 and smaller floods occurred in other years, before gage records started near Carver or at Chaska. Undoubtedly, there were floods also in Chaska during these same years.

17. The largest flood at Chaska from overflow of the creeks, for which there is detailed information available, occurred in the late evening of 20 July 1951. The flood-producing storm covered portions of southern and central Minnesota with widely varying amounts of rainfall. In the vicinity of Chaska the rainfall occurred approximately from 8 p.m. on 20 July until 2 a.m. 21 July. Rainfall at the Weather Bureau gage, 1 mile northeast of Chaska, totaled 3.95 inches. It was reported that a downpour of rain lasted 1 hour and 45 minutes and that the total amount of rainfall at Chaska was 4½ inches. Within 1½ hours, the creeks spread over two sections of the city. Although not as extensive and devastating as the overflow from the Minnesota River in April 1951, it inflicted a sudden scare to residents in each of the creek sections. The floodwaters vanished almost as quickly after the rain ended as the inundation took place during the torrent downpour.

18. There is no known information on other floods on Chaska or East Creeks. Local residents have reported that other floods have occurred on both creeks and have caused damage, but no dates or details are available.

FLOOD FREQUENCY CURVES

19. MINNESOTA RIVER AT CHASKA, MINN.

River stages at Chaska on the Minnesota River are often affected by backwater from the Mississippi River. There is no single rating curve at Chaska, so an elevation-frequency curve was derived rather than a discharge-frequency curve and a rating curve. The elevation-frequency curve for Chaska, used in the present studies, is one of a series of elevation-frequency curves developed at various communities on the lower Minnesota River. The curves were derived in the following manner. A discharge-frequency curve for the Mississippi River at St. Paul, Minn. (based on approximately 100 years of records) was transferred 5 miles upstream to the mouth of the Minnesota River, near Mendota, Minn., and converted into an elevation-frequency curve. A discharge-frequency curve was derived from 31 years of records at the Carver gaging station, correlated with longer records at Mankato and at St. Paul. This discharge-frequency curve was converted to an elevation-frequency curve. This elevation-frequency curve represents conditions near the upstream limits of the backwater effect from the Mississippi River. Profile lines were drawn between the mouth of the Minnesota River and the Carver gaging station showing the relationship of stage and river miles for various frequencies. A profile of the 1965 flood (approximately a 100-year flood) indicated that a straight-line profile is reasonable. Then the elevations of the profile lines at mile [illegible] were used to obtain the elevation-frequency curve for the Minnesota River at Chaska. The same procedure was used for both annual and all-independent peak curves. These frequency curves are shown on plate B-2. Possible revision of these frequency curves, due to updating with additional records, will be analyzed in postauthorization studies.

20. CHASKA CREEK

There are no discharge records on Chaska Creek or on East Creek. The instantaneous peak frequency curve for Chaska Creek was determined by a method of the Soil Conservation Service proposed by Howard Cook and called the sigma (W) method. This method is described in an article "Computing Runoff from Small Watersheds," by C. L. Hamilton in Public Works Magazine, August 1965. The method involves determining coefficients (W) for various basin characteristics of relief, soil conditions, vegetal cover, and surface storage; summing the coefficients (W); and determining by means of a curve the basic 25-year discharge using the drainage area and sum of (W) as known factors. The basic 25-year discharge is then modified by a basin shape factor for the final 25-year discharge. The 10-, 50-, and 100-year discharges are taken as percentages of the 25-year discharge.

21. Chaska Creek at First Street Bridge has a drainage area of 14.8 square miles. The total value of (W) for the basin with existing conditions was estimated as 49. The basic 25-year peak for this area is

5,500 cfs. Adjusting this by a rainfall factor of 0.82 and a shape factor of 0.56 gives a 25-year frequency peak of 2,520 cfs. Frequency factors give the following peaks: 100-year, 3,750 cfs; 50-year, 3,100 cfs; 10-year, 1,800 cfs. The frequency curve computed by this method, which is for existing conditions, is shown on plate B-3. Postauthorization studies will include an analysis of various methods of developing synthetic frequency curves along with a recommendation of the best method for use in this study.

22. For future conditions, information was obtained from local authorities on the anticipated future development of the Chaska Creek basin. The anticipated development will not be great, as 55 percent of the area will remain as open space, greenways, and parks, while the remainder will be medium or low density residential, commercial, industrial, highway, and other types of areas. The weighted increase in peak runoff from the various expected kinds of areas was estimated and it was determined that peak flows with future development would be 25 percent greater than under existing conditions. The discharge-frequency curve showing discharges increased by 25 percent for future conditions is also shown on plate B-3.

23. EAST CREEK

Discharge-frequency curves were computed for East Creek at the proposed point of diversion, about 1 3/4 miles northeast of the business district of Chaska. The total drainage area at this point is 10.5 square miles. Of this area, 1.18 square miles are above the outlet of Lake Bavaria, 0.83 square mile is above the outlet of Hazeltine Lake, and 0.79 square mile is below Hazeltine Lake but above Highway 41. The peak frequencies were computed from an effective drainage area of 7.7 square miles, plus flow from above Highway 41, plus Lake Bavaria outflow. In 1968, a small dam was built across East Creek forming Lake Grace. The effective drainage area above Lake Grace Dam is 3.93 square miles. A second dam has been proposed for East Creek near the railroad crossing, above Lake Grace Dam. The maximum height would probably be about 18 feet. It would have an effective drainage area of 3.21 square miles. These drainage areas are shown on the map on plate B-1.

24. Discharges were determined for East Creek at the proposed point of diversion for natural conditions (before Lake Grace Dam was built) in the same manner as for Chaska Creek. The total (W) value of East Creek basin was estimated as 52.5. With an effective drainage area of 7.7 square miles, the basic 25-year peak flow would be 4,350 cfs. Adjusting for a rainfall factor of 0.82 and a shape factor of 0.68, the 25-year peak flow from the effective area becomes 2,420 cfs. The 100-year peak is 3,630 cfs and the 10-year peak is 1,720 cfs. An additional flow, varying from 100 cfs for the 100-year flood to 50 cfs for the 10-year peak, was added for flow from each of the two lakes. This frequency curve, labeled natural conditions, is shown on plate B-3.

Nearly all of the Eask Creek basin lies within a planned community, called "Jonathan New Town" which will have a limited planned development. Peak runoff was computed from the 7.7-square mile area with future development, but neglecting Lake Grace Dam and the proposed dam. With a total (W) of 65, the 25-year peak flow amounts to 3,900 cfs. Other peak flows are: 100-year, 5,850 cfs; 50-year, 4,800 cfs; and 10-year, 2,770 cfs. This amounts to about a 61-percent increase over natural conditions.

25. In order to determine the effect of the one or two dams on East Creek it was necessary to derive hydrographs at the damsites for routing and for areas below the damsites. Time of concentration for runoff on pertinent areas and travel times were determined and are shown in table B-2.

Table B-2 - Times of concentration and travel times at pertinent points, East Creek

Location	Area number	Drainage area (sq mi)	Time of concentration: Local area (hours)	Time of concentration: At point (hours)	Time of travel (hours)
Present conditions					
	3	3.20	1 1/2		
At proposed dam				1 1/2	
	2	0.72	3/4		1/2
At Lake Grace Dam				2	
	1	3.79	2		1
At point of diversion		7.71		3	
Future conditions					
	3	3.20	1 1/4		
At proposed dam				1 1/4	
	2	0.72	3/4		1/2
At Lake Grace Dam				1 3/4	
	1	3.79	2		1
At point of diversion		7.71		2 3/4	

26. Because of the small size of drainage areas, the hydrographs were related directly to rainfall frequency. Rainfall was obtained for the time of concentration of the effective area above the proposed point of diversion. The rainfall is from the Weather Bureau Technical Paper

No. 40, "Rainfall Frequency Atlas of the United States." The following rainfall depths were used:

		100-year	10-year
Natural conditions	Tc = 3 hours	3.88 inches	2.67 inches
Future conditions	Tc = 2 3/4 hours	3.80 inches	2.65 inches

Triangular hydrographs for runoff from the 7.7-square mile area above the point of diversion were computed for natural conditions (no dams) using the 3-hour rain and with the discharge peak at 3 hours. This is a form of the rational method. With the whole area contributing, the runoff coefficients would be 0.57 for the 100-year flood and 0.39 for the 10-year flood. The coefficients are ratios that must be multiplied by the rainfall to obtain excesses which will produce peak discharges equal to those shown at the same frequencies on the frequency curve (by the sigma (W) method) for natural conditions. For future developed conditions, the runoff coefficients would be higher. Postauthorization studies will include an analysis of Snyder's synthetic unit hydrographs as applied to these small drainage areas.

27. As there is now one dam on East Creek, a 100-year flood hydrograph was derived for the 3.93 square mile area above Lake Grace Dam and another hydrograph was made for the 3.79-square mile area below the dam. The hydrographs are for the 3-hour 100-year rainfall, assumed to be of uniform intensity throughout the 3 hours, and no rain before or after. The discharge hydrographs for these subareas were made trapezoidal in shape, rising from the start of the rain until the time of concentration of that area is reached, then having a uniform discharge while the whole area is contributing until the end of the 3 hours of rainfall, and then dropping to no flow in a length of time equal to the time of concentration. The maximum value of each of the trapezoidal hydrographs is proportional to the drainage areas and the peak for the total area at the point of diversion. This is because the peak values of each area represent runoff from the entire drainage area at the same intensity of rainfall excess. Then by lagging the hydrograph from the upper area by the time of travel and adding it to the hydrograph for the lower area, the combined peak flow equals the peak for the total area for natural conditions as shown on the frequency curve for natural conditions, excluding lake outflows. The same procedure was followed for the 10-year flood using the 10-year, 3-hour rainfall and runoff factor that would give the 10-year peak at the point of diversion. Hydrographs were then available for routing through Lake Grace.

28. Hydrographs were also made in a similar manner for future conditions, with land development, but using rainfall intensity for 2 3/4 hours (time of concentration) and a higher rainfall-runoff factor. Also, the area was further subdivided to obtain hydrographs for three areas to allow routing through the proposed dam, as well as the existing dam. The peak values of the hydrographs are shown in table B-3.

Table B-3 - Hydrograph peaks for subareas and total effective area without Lake Grace - East Creek

Flood and condition	Peak discharge in cfs: Area 3, 3.20 square miles proposed dam	Area 2, 0.72 square mile Lake Grace	Area 1, 3.79 square miles diversion	Total area(1), 7.71 square miles diversion
10-year, natural	715(2)	160(2)	845	1,720
100-year, natural	1,510(2)	340(2)	1,780	3,630
10-year, future	1,150	260	1,360	2,770
100-year, future	2,430	550	2,870	5,850

(1) Discharges are from frequency curve computations for this area.
(2) For present conditions, areas 3 and 2 were combined.

29. Storage-elevation and outflow rating curves were drawn for the existing Lake Grace Dam and Reservoir from available data. No data are available for the proposed dam across East Creek above the railroad crossing. An elevation-storage curve was estimated from a topographic map, but necessitated modifying the storage curve for Lake Grace, which extended above the proposed dam. A crest length of 180 feet was assumed for the proposed dam, as this would allow a 2-foot head on the spillway for a 100-year flood.

30. Reservoir routing and combining were performed by use of the computer program "Hydrograph Combining and Routing" (HEC). For natural conditions, modified by Lake Grace, a constant assumed outflow from the two lakes was added to the hydrograph for the 3.93-square-mile area (natural conditions) above Lake Grace Dam. This inflow was routed through Lake Grace, routed down to the proposed point of diversion, and combined with the hydrograph from the lower area. This was done for 100-year and 10-year floods. Similar routing and combining were performed using hydrographs for future developed conditions and the existing Lake Grace. The peak flows at the point of diversion from these routings were used to plot the top curve that is shown on plate B-3.

31. Some development has taken place in the East Creek basin since the frequency curve for natural conditions was derived. Also, the Lake Grace Dam was constructed. The difference in discharge of the two frequency curves, (1) natural conditions but with Lake Grace Dam in operation, and (2) future conditions with Lake Grace Dam, were obtained at selected frequencies. Ten percent of this difference in discharges of the frequency curves was added to the frequency curve for natural conditions with Lake Grace to account for the partial development in the basin. A frequency curve derived from these values is included on plate B-3 and is labeled "Existing Conditions, with Lake Grace Dam."

32. Another set of routings was done with hydrographs for the three subareas under future conditions. The proposed dam above the railroad and the existing Lake Grace Dam were assumed to be in operation. The hydrographs were routed through the downstream reservoirs and to the proposed point of diversion and combined. These computed discharges were used to derive the frequency curve labeled "Future Conditions with Two Dams," which is also shown on plate B-3.

STANDARD PROJECT FLOODS

33. MINNESOTA RIVER AT CHASKA

A standard project flood has previously been derived for the Minnesota River near Carver. This standard project flood has a peak of 165,000 cfs. The derivation is given in "Report on Probable Maximum Floods and Standard Project Floods for Minnesota River Basin, Minnesota," by the St. Paul District office, dated January 1971. This peak value was based on an adopted standard project flood at Mankato of 155,000 cfs and drainage area relationships of peak flows for floods of record. The drainage area at the Mankato gage, 14,900 square miles, is 8 percent less than that at the Carver gage. The Mankato standard project flood was determined in a lengthy investigation of the Minnesota River basin, which involved dividing the basin into seven subareas and using routing and combining procedures. Floods were computed for the all-season (summer) storm and various combinations of spring snowmelt and rainfall runoff. The adopted standard project flood at Mankato, 155,000 cfs, is from a combination of rainfall immediately following the snowmelt runoff.

34. The drainage area of the Minnesota River at Chaska, shown on plate 1 of the main report, is approximately 16,600 square miles while that at the Carver gaging station is 16,200 square miles. The standard project flood drainage area line from Mankato to Carver, on plate 27 of the above-mentioned report, was extended to 16,600 square miles. This line represents approximately the 0.7 power of the drainage area ratio. The standard project flood for the Minnesota River at Chaska is then determined to be 168,000 cfs.

35. CHASKA CREEK

A standard project flood was computed for Chaska Creek at the proposed point of diversion (drainage area 14.4 square miles) and another for the First Street Bridge (drainage area 14.8 square miles). As the areas are small, the standard project flood was obtained by having the entire basin contributing from a standard project storm of duration equal to the time of concentration. The time of concentration was computed from the maximum length of travel and the difference in elevation. For both sites the time of concentration was used as 4 hours. The standard project storm is obtained from data in EM 1110-2-1411 (formerly Engineer Bulletin 52-8). Index rainfall for the basins is 10 inches. Rainfall depths for both sizes of areas are practically the same. Charts do not give directly the maximum 4-hour rainfall depths, so the

maximum rainfall for 2-, 3-, 6-, and 24-hour duration was plotted and a curve drawn. From this curve the maximum 4-hour standard project flood rainfall was read as 7.32 inches. A uniform loss rate of 0.10 inch per hour was used. This is the adopted loss rate for a standard project storm in the Minnesota River basin studies. The 4-hour rainfall excess is 6.92 inches, which is a rate of 1.73 inches per hour. This rate of runoff, with the whole basin contributing, gives a peak flow of 16,100 cfs for 14.4 square miles and 16,500 cfs for 14.8 square miles. No base flow is added for these small areas. These values are adopted for the standard project floods on Chaska Creek at the proposed point of diversion and at the First Street Bridge in Chaska, respectively.

36. EAST CREEK

A standard project flood was computed for East Creek at the proposed point of diversion (effective drainage area of 7.72 square miles) for existing conditions. As for Chaska Creek, the standard project storm was computed for a duration equal to the time of concentration of the total effective basin. However, because of storage in Lake Grace, a number of periods of rainfall were determined and hydrographs were derived for areas above and below Lake Grace. The time of concentration for the effective drainage area of 7.72 square miles is 3 hours under existing conditions, but neglecting effect of Lake Grace and the dam. Times of concentration and travel times for the basin and subareas are given in table B-2. With an index rainfall of 10.0 inches and for 10.0 square miles (the minimum on the graph) the 24-hour rainfall is 11.75 inches, and the maximum 6-hour rainfall is 9.29 inches. As before, the uniform loss rate is assumed as 0.10 inch per hour. Rainfall and rainfall excess for the maximum 12 hours by 3-hour periods are given in table B-4.

Table B-4 - Standard project storm rainfall and excess by 3-hour periods, East Creek

Item	Depth in inches by 3-hour periods			
	1	2	3	4
Rainfall	3.07	6.22	0.86	0.42
Rainfall excess	2.77	5.92	0.56	0.12

37. The standard project flood at the point of diversion was developed using the same procedures and routing methods discussed in paragraphs 25, 26, 27, and 30. The peak flow from the area above Lake Grace Dam was 5,000 cfs. It is likely that this inflow will cause the dam to be overtopped. We have assumed that there would be no failure of the dam under this condition. Furthermore, we have assumed that the railroad embankment and culvert located approximately 1 mile upstream of Lake Grace Dam have only minor effect on the runoff

from the drainage area above that point. Postauthorization studies will include a further analysis of this problem and possible effects of dam failure. The area below Lake Grace Dam peaked at 4,820 cfs. A constant flow of 200 cfs was added to the upper area flow to allow for flow from Lake Bavaria and Hazeltine Lake, giving a total maximum flow of 5,200 cfs. The hydrograph from the upper area was routed through Lake Grace and downstream where it was combined with the hydrograph from the lower area at the proposed point of diversion. The peak flow is 8,430 cfs which is the standard project flood for existing conditions at the proposed point of diversion. The standard project flood hydrograph is shown on plate B-4.

PROBABLE MAXIMUM FLOOD

38. A probable maximum flood was computed for East Creek at the proposed point of diversion. Because of the extremely large flows, lack of information on the outlet rating of the dam for very high stages, and the possibility of failure, no routing was performed through the existing Lake Grace Reservoir and the dam. The probable maximum flood was computed for runoff of the total contributing area of 7.71 square miles as a unit. The time of concentration to the point of diversion is 3 hours. Runoff was computed from the maximum 3 hours of the probable maximum precipitation, which would be the maximum rate at which the entire basin would contribute at this point. The rainfall is from the U.S. Weather Bureau Hydrometeorological Report No. 33,"Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian . . .", April 1956. The all-season index rainfall for this location is 21.6 inches. At 10 square miles, the smallest area shown on the graph, the maximum 6-hour precipitation becomes 25.25 inches. This amount was reduced by the so-called "Hop Brook factor" as described in Engineer Circular No. 1110-2-27, dated 1 August 1966. For 10 square miles this reduction is 20 percent which gives an adjusted 6-hour precipitation of 20.20 inches. The 6-hour precipitation was divided into 3-hour amounts by the ratio of 67 percent and 33 percent in conformity to the Engineer Circular. Placing the smaller rain first, the 6.66 inches in the first 3 hours greatly exceeds the initial loss, usually assumed as 0.50 inch in this vicinity. The maximum 3-hour rainfall amounts to 13.54 inches. Subtracting a uniform loss of 0.05 inch per hour, or 0.15 inch in 3 hours gives a maximum 3-hour rainfall excess of 13.39 inches. The maximum discharge from 7.71 square miles of drainage area from this rainfall excess is 22,000 cfs. Adding an assumed flow of 400 cfs from the two lakes gives a total flow of 22,400 cfs for the probable maximum flood at the proposed point of diversion. Possible effects of dam failure at Lake Grace Dam will be investigated in postauthorization studies.

HYDRAULICS

39. GENERAL

Approximately 2.1 miles of channel works are proposed within the corporate limits of Chaska, 1.2 miles on East Creek, and 0.9 mile on Chaska Creek. Of the 2.1 miles, about 2 miles of riprap channel and 0.1 mile of concrete channel and drop structures are planned. Short lengths of levees are required from the flood bypass structure on East Creek to County-State-Aid Highway 17 and downstream of the First Street Bridge on Chaska Creek. In both cases, interference with interior drainage is either minimal or nonexistent. Approximately 1.8 miles of levee along the Minnesota River at Chaska is also proposed. Proposed heights of levees for protection from the Minnesota River are 4 feet above the Corps of Engineers 100-year flood profile. This amount of freeboard was applied because the U.S. Geological Survey 100-year profile through Chaska is 1 foot higher than that of the Corps. Water surface profile studies are being continued by the U.S. Geological Survey.

40. CHANNEL DESIGN

The proposed channels for both Chaska and East Creeks were designed to provide protection for the intermediate regional floods, 4,700 cfs and 4,350 cfs, respectively, for future conditions. Manning's formula was used to design the proposed channels. For the riprap sections, the roughness coefficient varied from 0.029 to 0.04 depending upon the thickness of the riprap layer, while for the concrete channel sections the roughness coefficient was assumed to be 0.013. Riprap design followed procedures outlined in U.S. Army Corps of Engineers Publications, EM 1110-2-1601 and ETL 1110-2-120. In addition, two other references were consulted, "Use of Riprap for Bank Protection" by U.S. Department of Transportation, Hydraulic Engineering Circular No. 11, and "Design of Small Dams" by the Bureau of Reclamation.

41. Typical channel sections, plan and profile for both creeks are shown in plates 4 and 5 of the main report. Tables B-5 and B-6 contain the proposed channel characteristics for the Chaska Creek diversion and East Creek flood bypass. Channel velocities are subcritical except for the concrete channel section of the Chaska Creek diversion and the riprap channel section downstream of Stoughton Avenue on the East Creek flood bypass channel which are supercritical. Where applicable, channel bottom widths were chosen to minimize channel widths, thereby reducing right-of-way requirements and bridge costs.

Table B-5 - Proposed channel characteristics, Chaska Creek diversion channel

Station	Bottom elevation (feet)	Bottom width (feet)	Channel protection	Side slopes	Average velocity (fps)
0+00	700.1				
	Riprap apron				
1+65	700.1				
	Concrete drop structure				
2+00	702.1				
		8	Riprap	1 on 2.5	10.0
41+20	715.5				
	Concrete drop structure				
41+90	728.1				
		29.5	Concrete	Vertical	19.3
46+20	729.5				
	Concrete drop structure				
46+70	732.4				

Table B-6 - Proposed channel characteristics, East Creek flood bypass

Station	Bottom elevation (feet)	Bottom width (feet)	Channel protection	Side slopes	Average velocity (fps)
0+00	Sheet piling drop structure				
0+10	686.1	115	Riprap	1 on 4	12.2
15+70	730.1				
	Concrete drop structure				
16+20	737.4	8	Riprap	1 on 2.5	10.2
54+65	752.0				
	Concrete drop structure				
55+00	765.6	8	Riprap	1 on 2.5	10.2
63+65	768.9				

42. The East Creek flood bypass structure and channel were designed to contain the standard project flood due to the possibility of flood damages accruing in areas that previously would not have been flooded. Due to the much larger size of the standard project flood on Chaska Creek, when compared to the intermediate regional flood, 16,500 cfs to 4,700 cfs, no economical remedial measures can be taken to prevent the improved creek channel from overflowing into Chaska and ponding behind the levee.

43. Generally the channels were designed with 2 feet of freeboard, both concrete and riprap channels. All along the East Creek flood bypass channel, sufficient additional freeboard above channel freeboard is available to pass the standard project flood. The Chaska Creek diversion is a fairly deep cut within the critical breakout region from the U.S. Highway 212 bridge to 800 feet north of the First Street Bridge, and therefore no flooding would result should the channel freeboard be topped by as much as a foot. The concrete channel section on Chaska Creek upstream of the Milwaukee Road railroad crossing was necessary for two reasons: first, save the existing U.S Highway 212 bridge with minor improvements and second, fit the narrow corridor available between the city street and two houses upstream of the U.S. Highway 212 bridge.

44. LEVEE DESIGN

The proposed plan includes a 9,250-foot-long, 20- to 25-foot high levee along the Minnesota River at Chaska. Approximately 6,000 feet of existing emergency levee would be upgraded to current design standards. The remaining 3,250 feet would be new levee needed to tie into high ground. The levee would provide protection from the intermediate regional flood (100-year flood) on the Minnesota River with 4 feet of freeboard over the water surface profile as determined by the Corps of Engineers. Four feet of freeboard were applied since preliminary data received from the U.S. Geological Survey indicate that recent development in the floodplain downstream from Chaska may have caused increased flood stages at Chaska. Also, the selected levee height would be about 0.5 foot higher than the standard project flood and would provide protection against it. Further consideration will be given to the levee height during postauthorization studies.

45. HYDRAULIC STRUCTURES

Three types of drop structures are proposed for the Chaska Creek diversion, straight drop spillway stilling basins, an overflow weir drop structure, and impact basins. Design information was obtained from the following references: Technical Paper No. 15, St. Anthony Falls Hydraulic Laboratory; EM 1110-2-1601; and Design of Small Dams, Bureau of Reclamation, respectively. An additional reference consulted concerning the overflow weir drop structures was Technical Paper No. 2-762, Control Structure, Little Sioux River, Iowa. The impact basins are proposed for releasing flows into the planned

Chaska Creek diversion from a tributary stream located southwest of Hickory Street. More than adequate erosion protection is available at each structure.

46. A straight drop structure at the upper end of the Chaska Creek diversion maintains the existing upstream water surface profile. Chaska Creek utility crossings are listed in table B-7.

Table B-7 - Utility crossings

Item	Station	Modification
Chaska Creek diversion		
Water main, 6-inch	31+40	Replace on new bridge
Sanitary sewer, 8-inch	31+40	Siphon
Utility poles		Relocate
East Creek flood bypass		
Force main, 4-inch	16+90	Lower about 10 feet
Telephone cable	31+00	Replace on new bridge
Water main, 12-inch	56+90	Replace on new bridge
Sanitary sewer, 18-inch	62+00	Siphon
Brandondale utility conduit	63+00	Relocate

47. East Creek flood bypass channel contains two types of drop structures, the overflow weir drop structure and a sheet-piling drop structure. The one located south of Stoughton Avenue was modified to function additionally as a transition between the 8-foot and 115-foot bottom width channels. To accomplish this, a baffle was included to distribute the flow evenly across the entire bottom width, thereby minimizing the possibility of downstream riprap failure due to high localized velocities. The structure can easily pass the standard project flood. The sheet-piling drop structure serves to stabilize the riprap channel at its junction with the Minnesota River.

48. Additional investigation will be required during the postauthorization period to establish a design for the low-flow pipe through the East Creek flood bypass structure. Too large a flow coupled with heavy rains within the downstream tributary watersheds could cause some localized flooding along the stream channel. Current design calls for a 4-foot-diameter pipe with a sluice gate control structure consisting of a sluice gate and stop log grooves. It would allow up to a maximum of 220 cfs to pass through with the upstream water surface at 780.

49. BRIDGES

All proposed bridges possess a 3-foot freeboard from water surface for the intermediate flood to low steel or concrete. For the existing bridge on U.S. Highway 212, the freeboard was reduced to slightly less than 2 feet. It was not felt that the additional 1 foot of freeboard could justify a new bridge. The proposed road bridges were assumed to possess a curb-to-curb width of 46.5 feet. Only the proposed First Street crossing over the proposed Chaska Creek diversion would require a grade change, approximately a 3-foot raise, in order to cross the proposed levee and provide 3 feet of freeboard. Bridge losses are minimal due to the narrow channel widths, which allow the placement of bridge piers outside of the majority of the flow area.

50. RESIDUAL FLOODPLAIN

Even with the East Creek flood bypass, sufficient tributary area is available to generate minor flooding from approximately 1,000 feet upstream of the U.S. Highway 212 bridge to several hundred feet downstream of the Beech Street Bridge. The 100-year, 1-hour storm (3 inches) was used to compute the stream discharge. Flow was incrementally added along the stream reach, varying from 1,294 cfs at the levee to 1,180 cfs at the U.S. Highway 212 bridge, and finally to zero at the bypass structure (assuming the sluice gate on the low-flow conduit was closed). With the aid of the sections used to obtain the high water profile on East Creek and the Corps of Engineers water surface profile program, HEC-2, the profile was computed and plotted on plate E-4.

INTERIOR DRAINAGE

51. DRAINAGE AREA

The area tributary to the proposed project amounts to approximately 1.9 square miles (1,216 acres). The elevations in this area vary from 700 feet msl (mean sea level) to 920 feet msl. Approximately 1 mile north of the Minnesota River is an area of very steep hills and bluffs running roughly in a southwesterly-northeasterly direction. The bluffs rise 75 to 100 feet above the floodplain of East Creek in this area. Adjacent to the bluffs is an area of strong irregular slopes and hills with deeply eroded ravines containing Chaska and East Creeks. The northern and western part of the area has rolling slopes with frequent lakes, marshes, and peat bogs. Approximately 35 percent of the area, all within the corporate boundary of Chaska, is highly developed with urban construction including residential, commercial, and industrial development. About 10 percent of the area is partially occupied with urban development and the remainder of the area is agricultural lands, lakes, marshes, and generally undeveloped except for areas occupied by roadways,

highways, railroads, and small isolated urban developments which are rapidly being expanded. The proposed Chaska expansion area has extensive ravines, creeks, and open drainage ways which are intended to remain as open spaces in their natural condition. Maps used for the interior drainage study of this report include topography obtained by the Corps of Engineers, U.S. Geological Survey topography maps, topography obtained by consulting firms including surface drainage, sanitary sewer maps, waterline maps, city maps of Chaska, aerial photographs, 1965 flooded area map, and flood reconnaissance data.

52. PRESENT DRAINAGE

The existing drainage area to be protected by the proposed project is divided into four sections as shown on plate B-5. The drainage sections were delineated by the existing topography of the land areas, railroads, highways, watersheds of Chaska and East Creeks, streamlets, lakes, and streets; the existing drainage system; and reconnaissance surveys.

53. Section 1 (36 acres) is occupied by urban development on about 70 percent of the area. This area is crossed by the Minneapolis-St. Louis Railroad and existing Chaska Creek. The highly developed urban area of section 1 has no storm sewer system. Surface drainage is by way of paved streets and gutters that slope toward the river, and by streets, gutters, and culverts that drain into Chaska Creek.

54. Section 2 (52 acres) is occupied by urban development on nearly all of the area with residential and commercial construction. The area is bordered by an existing dike on the south side along a section of Chaska Creek and along a section of the Minnesota River. The existing dike provides some protection against floods and intercepts interior drainage from the surface runoff in Chaska. State Highway 41 passes through the southern section of the area. The area of section 2 has no storm sewer system. Surface drainage reaches the existing dike by the streets and gutters that slope toward the dike. Surface runoff collects in a low area at the terminus of Elm Street where it discharges through an existing 36-inch reinforced-concrete pipe gated outlet to Chaska Creek. The existing Elm Street outlet is connected to a pumping station with a capacity of approximately 9,000 gpm (gallons per minute). During floods, the pumps discharge over the top of the dike into a concrete flume. Surface drainage from State Highway 41 passes through the existing dike by a 24-inch reinforced-concrete pipe, provided with slide gates and end sections.

55. Section 3 (58 acres) is occupied by urban development on all of the area except on part of one city block between Ash and Maple Streets adjacent to the existing dike. The area of section 3 is occupied with residential and commercial construction. With adequate flood protection, it is anticipated that all of the area of section 3 will be

completely developed. Section 3 is bordered by an existing dike on the south side and the Milwaukee Road railroad on the north side. State Highway 41 passes through a portion of the area. The existing dike provides some flood protection and intercepts interior drainage. The area has no storm sewer system. Surface drainage reaches the existing dike by paved streets and gutters that slope toward the dike. Surface runoff collects in a low area near Maple Street adjacent to the dike. In this location, the runoff discharges through a 36-inch reinforced-concrete pipe gated outlet to the Minnesota River. The existing Maple Street outlet is connected to a pumping station with a capacity of approximately 9,000 gpm. During floods, the pumps discharge over the top of the dike into a concrete flume. Surface drainage from the Walnut Street area passes through the existing dike at the terminus of Walnut Street by an 18-inch reinforced-concrete pipe equipped with a slide gate and end section.

56. Section 4 (1,070 acres) is the largest area to be analyzed for interior drainage in the Chaska proposed flood control project. The drainage area of this section is tributary to East Creek and covers all of the East Creek watershed between the proposed East Creek diversion and the proposed levee crossing East Creek. The boundary of this large interior drainage area is shown on plate B-5. This area intercepts surface runoff from a small section of the highly developed urban old town area of Chaska which slopes to the north. The surface runoff reaches East Creek by paved streets, gutters, culverts under streets, and the railroad tracks. Surface drainage from the isolated urban developments and undeveloped areas also reaches East Creek. A portion of the surface runoff drains into some of the small lakes which were excavated for clay in the manufacturing of bricks. Section 4 is crossed by the Minneapolis-St. Louis railroad and is partly occupied by railroad sidetracks and switchyards. The section is also crossed by the Milwaukee Road tracks, State Highways 41 and 212, and numerous streets and roadways. Because of the variable elevations, lakes, swamps, and urban development, the drainage pattern is difficult to define. The area of section 4 has no storm sewer system. Surface drainage reaches East Creek and the Minnesota River by surface sheet runoff, by ditches adjacent to the highways and railroads, by streets, gutters, and natural watercourses. Some of the surface drainage is trapped in the lakes, swamps, and at the existing dike.

57. EXISTING SANITARY SEWAGE DRAINAGE

The highly developed old town district of Chaska, the isolated urban developed areas, and other proposed urban development areas of Chaska including the Jonathan model city area are served by a sanitary sewer treatment plant located in the southeast corner of the old town district of Chaska near the Minnesota River. Chaska is planning to upgrade the older sanitary sewerlines. The proposed flood control project in Chaska will protect the sewage treatment plant from floods.

The highly developed urban section of Chaska is provided with branch sewerlines on nearly every street adjacent to the proposed levee. The branch sewerlines connect to a trunk sewerline and force main paralleling the existing dike. Approximately 700 feet of the trunk sewerline is on the Minnesota River side of the existing dike and about 1,400 feet of the force main are under the existing dike. A sewage lift station is located on Oak Street landward of the existing dike which intercepts a gravity line and connects to the force main. The city of Chaska plans to construct a larger trunk sewerline landward of the existing dike to the sewage treatment plant. This sewerline will serve a large expansion urban district west of Chaska Creek.

58. SEEPAGE

Detailed seepage analysis for the proposed leveed areas has not been made but a preliminary seepage analysis from some soil test borings was made along the proposed levee alignment. Detailed seepage studies will be undertaken during postauthorization studies. The estimated seepage values for the various sections inclosed by the proposed levee are shown in paragraph 79, table B-11.

59. INTERIOR DRAINAGE PROBLEM

The proposed flood barrier alignment crosses the existing storm sewer outlets, culverts, water and other service lines, and sanitary sewer force mains and an outlet from the waste and sewage disposal plant. Positive control of these lines must be provided at the flood barrier by providing shut-off valves. Several water hydrants for fire protection must be relocated at the proposed flood barrier. A waterline to a hydrant must be modified at the sewage treatment plant. The storm water outlets, interceptor sewers, and pumping stations must be designed to dispose of the interior drainage surface runoff during floods and nonflood conditions. With the proposed levee, it will become necessary to provide interceptor sewers or drainage ditches where there is sufficient space between the landside toe of the levee and existing construction to transmit surface runoff that would collect at the levee to central locations in each section for pumping over the top of the levee during flood periods or discharge the runoff through adequate gravity outlets during nonflood periods.

60. In sections 2 and 3, it will be necessary to relocate approximately 2,100 feet of an existing sanitary sewerline and an additional 1,600 feet of the sewer will require modification or relocation. Of the 2,100 feet of sanitary line to be relocated, approximately 1,400 feet is an existing force main under the center line of the existing dike which will also become the alignment of the proposed levee. The additional 1,600 feet of the sewer line are on the landside of the existing dike. Modification or relocation will depend on the alignment of the proposed levee.

61. In section 1, it is assumed for this report that all surface runoff will be conveyed to the abandoned channel of Chaska Creek in future city drainage plans. In the survey report plan, Chaska Creek will be relocated between the Milwaukee Road and Minneapolis-St. Louis Railroad tracks. A detailed analysis will be made during postauthorization studies to determine the best location for the gravity outlet and the pumping station.

62. In section 2, an adequate gravity outlet and pumping station are proposed at the site of the existing Elm Street gravity outlet and pumping station. The existing discharge facilities at this location do not provide sufficient capacity for the design interior drainage discharges. A problem remains whether it is more economical to utilize the existing facilities with the proposed pumping station and gravity outlet plan or to abandon the existing facilities. A detailed analysis will be made during postauthorization studies to determine the condition of the pumps and gravity outlet facilities and if these facilities will be suitable to be included in the proposed pumping station plans. The problem of providing a pumping station in the area of section 1 and a pumping station in the area of section 2 or combining the two areas by conveying the coincidental rainfall runoff by interceptor pipes to a central location for one pumping station will be determined for the best and most economical plan in a detailed analysis during postauthorization studies.

63. In section 3, an adequate gravity outlet and pumping station is proposed at the site of the existing gravity outlet and pumping station near Maple Street. The existing facilities at this location do not provide sufficient capacity for the design interior drainage discharges. Here also a problem remains, whether it is more economical to utilize the existing facilities with the proposed pumping station and gravity outlet plan or to abandon the existing facilities. A detailed analysis of the existing facilities will be made during postauthorization studies to determine the condition of the pumps, the condition of the existing gravity outlet and if these facilities will be suitable to be included in the proposed pumping station and gravity outlet plan.

64. The existing pumping facilities and gated gravity outlets at the Elm Street and Maple Street locations in sections 2 and 3, respectively, do not meet Corps of Engineers standards proposed in the Engineering Manuals. The existing facilities will require considerable modifications to meet the standards stipulated in the Engineering Manuals. These units may be utilized as emergency standby equipment or to pump very low discharges to economize on operating costs for the larger proposed pumping stations. For this report, no credit for the existing pumping facilities will be made.

65. In the area of section 4 there are no existing pumping facilities. A pumping station and gravity outlet are proposed at the proposed levee crossing East Creek. The proposed pumping station will be a component of approximately 60 acre-feet of available ponding in the

proposed city park area around the east and south sides of Courthouse Lake and the proposed levee. When more ponding storage is required, about 60-acre feet of ponding in Courthouse Lake will be utilized. Ponding of surface rainfall runoff in Courthouse Lake will be limited to infrequent periods. Courthouse Lake is recharged from groundwater and currently supports a put and take trout fishery. The major problem in the area of section 4 is to provide dependable structures from East Creek to Courthouse Lake for use of the lake's storage as a component of the proposed pumping station. Detailed studies of a suitable control structure at Courthouse Lake in conjunction with the proposed pumping station and available ponding area will be made during postauthorization studies.

INTERIOR DRAINAGE PLANS

66. GENERAL

For this report, interior drainage plans were considered for Class II urban development for all sections. The old town district of Chaska is almost totally developed including some of the isolated sections in the expanded area of Chaska. It is assumed that in the future a high degree of development will occur in all of the expanded area of Chaska, including the area in which rainfall runoff is tributary to the proposed levee. The interior drainage plan for this report consists of six gravity outlets varying in sizes from 18 inches to 108 inches in diameter; one gravity inlet into Courthouse Lake without a gate well; six gate wells for gravity outlet pipes, approximately 5,300 feet of interceptor pipe; and approximately 1,600 feet of ditches to convey rainfall runoff to gravity outlets and pumping stations; four pumping stations; one gate well for a control structure from East Creek to Courthouse Lake; one gate well at the proposed levee for a discharge line from the sewage treatment plant; relocation of a sanitary sewer mainline approximately 3,700 feet in length; and waterline alterations at three locations. Ponding areas are considered at two locations in section 4 as components of a pumping station. The Minnesota River stage at which the outlet gates will be closed and the coincidental rainfall runoff related to pumping capacity design are based on elevation 705.0 msl, or 5 percent of time for the areas of sections 1, 2, and 3; and elevation 706.0 msl, or 3 percent of time for the area of section 4. These elevations were selected as a minimum damage stage from interior drainage rainfall runoff. A detailed survey of all the areas at the gravity outlet and pumping station sites will be made during postauthorization studies to determine the upper damage limit from interior drainage runoff. The coincidental frequency rainfall runoff at each pumping station is small in comparison to the 50-year frequency rainfall runoff selected for the gravity outlets. For this report, the interceptor sewers and ditches are based on the 50-year frequency rainfall runoff conditions. In postauthorization studies, it will be determined if interceptor pipes between outlet locations could be reduced in size to convey coincident rainfall runoff to the pumping stations in the areas of sections 2 and 3 by providing additional gate wells and gravity outlets in each area, or to use larger interceptor pipes to convey rainfall runoff to one gravity outlet in each section.

67. SUMMARY OF DESIGN DATA

Stage duration curves for the Minnesota River at Chaska were developed for two locations. One location is at the outlet of East Creek and the other location is at the outlet of Chaska Creek. The stage duration curves are shown on plates B-6 and B-7 for East and Chaska Creeks, respectively. Point rainfall-depth-duration frequency curves for Chaska are shown on plates B-8 and B-9. For this report, coincidental rainfall-river stage related to pumping station design is based on the Minnesota River discharge and stage data at Carver, Minn., river mile 31.9, for the period 1934 to 1965 inclusive, and transferred to Chaska, Minn., by slope relations to river mile 29.6, the junction of Chaska Creek and river mile 28.1, the junction of East Creek. Gate closure elevation for activation of pumps for this report is given for the stage-duration locations at the junction of Chaska Creek for the areas in sections 1, 2, and 3, and at the junction of East Creek for the area in section 4. Locations for the proposed gravity outlets, pumping stations, interceptors, and ditches are shown on plate B-5.

68. In section 1 (36 acres) the proposed interior drainage plan will consist of a 54-inch reinforced-concrete pipe gravity outlet, location A (plate B-5), placed through the proposed levee in the abandoned channel of Chaska Creek. The outlet will be provided with a gate well, sluice gate, inlet section, and a suitable end section with an energy dissipator if required. The capacity of the proposed Chaska Creek pumping station will be approximately 23,800 gpm. The design coincidental rainfall frequency of 2.5-year recurrence interval or 40 events per 100 years for Class II urban development was derived from a gate closure elevation 705.0 feet msl. Existing abandoned pipes discovered from an inspection trench will be plugged with concrete or removed from the proposed levee alignment.

69. The proposed interior drainage plan for the area of section 2 (52 acres) will consist of two 24-inch to 48-inch reinforced-concrete pipe interceptors extending upstream and downstream from the proposed gravity outlet and pumping station. The total length of the interceptors is approximately 3,300 feet. The interceptors will convey surface runoff from the 50-year and coincidental rainfalls that will collect at the levee to a 54-inch reinforced-concrete pipe gravity outlet or to the pumping station. Since the surface drainage will follow the paved streets that slope toward the levee in the old town area of Chaska, sufficient catch basins will be provided to intercept the surface drainage. In the area of section 2, approximately 1,700 feet of the existing sanitary trunk sewerline located along the toe of the existing dike will be relocated for the proposed levee. An existing 24-inch reinforced-concrete pipe outlet at Chestnut Street will be modified for the proposed levee section. The proposed 54-inch gravity outlet, location B, will be equipped with a gate well, sluice

gate, end sections, and an energy dissipator if required at the outlet end of the pipe. The gravity outlet and pumping station will be located near Elm Street. The capacity of the proposed Elm Street pumping station will be approximately 56,600 gpm and will discharge over the top of the levee into the gate well of the gravity outlet during flood periods. The design coincidental rainfall frequency of 2.5-year recurrence interval or 40 events per 100 years for Class II urban development was derived from a gate closure elevation 705.0 feet msl. Existing abandoned pipes discovered from an inspection trench will be plugged with concrete or removed from the proposed levee alignment.

70. The proposed interior drainage plan for the area of section 3 (58 acres) will consist of approximately 2,000 feet of 30- to 66-inch reinforced-concrete pipe interceptors to convey surface runoff from the 50-year and coincidental rainfalls that will collect at the toe of the proposed levee to a 72-inch reinforced-concrete pipe gravity outlet, location C, or to the pumping station. The existing 18-inch reinforced-concrete pipe outlet at Walnut Street will be modified for the proposed levee section. Since the streets of the old town area of Chaska slope toward the levee, sufficient catch basins will be provided to intercept the surface runoff. The proposed pumping station and gravity outlet will be located near Maple Street. The gravity outlet will be equipped with a gate well, sluice gate, end sections and energy dissipator if required at the storm sewer outlet. The proposed Maple Street pumping station will have a capacity of approximately 59,200 gpm and will discharge over the top of the levee into the gate well of the gravity outlet during flood periods. The design coincidental rainfall frequency of 2.5-year recurrence interval or 40 events in 100 years for Class II urban development was derived from a gate closure elevation 705 feet msl. Approximately 1,900 feet of the sanitary sewer trunk line, gravity flow and force main which is mostly under the existing dike will be plugged for the proposed levee. An 8-inch valve will be installed on the sanitary force main at the proposed levee alignment. Existing abandoned pipes discovered from an inspection trench will be plugged with concrete or removed from the proposed levee alignment.

71. The proposed interior drainage plan for the area in section 4 (1,070 acres) will consist of two 108-inch reinforced-concrete pipe gravity outlets equipped with a gate well, sluice gates, end sections including an energy dissipator if required. The gravity outlet will be placed in East Creek at the proposed levee crossing, location D. The outlet capacity is adequate to permit discharges from the 50-year frequency rainfall without any reduction in size due to temporary ponding. A pumping station with a capacity of approximately 84,000 gpm will be placed near the outlet location. The pumping station will be a component of Courthouse Lake ponding area and the ponding area adjacent to Courthouse Lake. The pumping station will discharge over the top of the proposed levee into the gravity outlet gate well or some other suitable structure. The design coincidental rainfall frequency of 1.4-year recurrence interval or 70 events in 100 years for Class II

urban development was derived from a gate closure elevation 706.0 feet msl. For this report, the gravity outlet will not be reduced in size as a component of available ponding because the potential ponding area adjacent to Courthouse Lake will be developed into a park. The ponding area will only be used in flood periods when the gravity outlet will be closed and pumping will be required. A 72-inch reinforced-concrete pipe with a gate well, sluice gate, and end section will be constructed between East Creek and Courthouse Lake at location E. An interceptor ditch is proposed along the landside toe of the proposed levee between East Creek and the northerly limits of the levee. No drainage ditch or interceptor pipe is proposed along the landside toe of the proposed levee between East Creek and the Milwaukee Road tracks. A 42-inch reinforced-concrete pipe with a flap gate will be constructed between the Carver County Court House drainage area and Courthouse Lake to intercept surface drainage at location F. The area between the proposed levee and Courthouse Lake will be landscaped and sloped to drain to East Creek. A gate well and 21-inch valve will be installed at the proposed levee alignment on the existing 21-inch cast-iron pipe discharge line from the sewage treatment plant. Detailed analysis of the drainage patterns in the area of section 4, the proposed ponding areas, and hydraulic design of structures in East Creek to pass runoff from the standard project rainfalls will be made during postauthorization studies.

72. ALTERNATIVES CONSIDERED

An alternative plan was considered in the area of section 4 for a diversion ditch from East Creek from a higher section of the East Creek watershed. The diversion ditch would pass around the north end of the proposed levee and thus prevent runoff from entering the proposed protected area. The diversion ditch would intercept runoff from approximately 745 acres. The remaining area would leave runoff from approximately 325 acres to enter the proposed flood-protected area. The diversion ditch would pass under State Highway 212, the Minneapolis-St. Louis Railroad tracks, and through a developed residential section. Runoff from the 50-year frequency rainfall would require a 169- by 107-inch concrete arch, 700 feet in length with appropriate end sections. An open ditch approximately 3,900 feet in length would be required to pass a flow of about 1,065 cfs. This plan was dismissed as too costly.

INTERIOR DRAINAGE DESIGN CRITERIA

73. REFERENCFS

Interior drainage design criteria references that were used and are to be used in postauthorization studies are:

a. EM 1110-2-1405, Flood Hydrograph Analyses and Computations.

b. EM 1110-2-1410, Interior Drainage of Leveed Urban Areas: Hydrology.

c. EM 1110-2-1411, Standard Project Flood Determinations (Civil Works Engineer Bulletin No. 52-8, March 1952).

d. EM 1110-2-3101, Pumping Stations - Local Cooperation and General Considerations.

e. EM 1110-2-3102, General Principles of Pumping Station Design and Layout.

f. EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations.

g. TM5-814-1, Sewage and Waste Disposal: Sanitary and Industrial Waste Sewers.

h. TM5-814-2, Sewage and Waste Disposal: Sewage Pumping Stations.

i. TM5-820-1, Drainage and Erosion Control: Surface Drainage Facilities and Airfields.

j. EM 1110-345-283, Drainage and Erosion Control Structures for Airfields and Heliports.

k. TM5-820-4, Drainage for Areas other than Airfields.

l. Hydraulic Design Criteria, Waterways Experiment Station, Vicksburg, Mississippi (Volumes 1 and 2).

m. Hydraulic Charts for the Selection of Highway Culverts, Hydraulic Engineering Circular No. 5, U.S. Department of Commerce, Bureau of Public Roads (1964).

n. Hydraulic Design of Improved Inlets for Culverts, U.S. Department of Transportation, Federal Highway Administration.

o. Design Charts for Open-Channel Flow, U.S. Department of Commerce, Bureau of Public Roads (1961).

p. Recommended Standards for Sewage Works, Great Lakes-Upper Mississippi River Board of State Sanitary Engineers (1968).

q. Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers, Manual of Engineering Practice No. 37 (1960).

r. Standards of the Hydraulic Institute, 12th Edition (1969).

s. Evaluation of Flared Outlet Transitions, Research Report H-72-1, Waterways Experiment Station, Vicksburg, Mississippi.

t. Evaluation of Three Energy Dissipators for Storm Drain Outlets, Research Report H-71-1, Waterways Experiment Station, Vicksburg, Mississippi.

u. Practical Guidance for Estimating and Controlling Erosion at Culvert Outlets, Miscellaneous Paper H-72-5, Waterways Experiment Station, Vicksburg, Mississippi.

v. Erosion and Riprap Requirements at Culvert and Storm Drain Outlets, Research Report H-70-2, Waterways Experiment Station, Vicksburg, Mississippi.

74. DEGREE OF PROTECTION

The area to be protected was divided into four sections. The four sections were considered class II urban development as defined in EM 1110-2-1410. The degree of protection is based on charts 1 and 2 of EM 1110-2-1410. The design of gravity outlets, interceptor sewers and ditches for the nonflood gravity discharge conditions for all areas is based on chart 1 and class II urban development as shown in table B-8. Paragraph 3-03 of EM 1110-2-1410 defines the ponding designations A through D. During postauthorization studies, stage A, B, and D conditions will be investigated.

Table B-8 - Rainfall frequencies for nonflood conditions for sections 1, 2, 3, and 4 (class II urban development)

Pond stage	Frequency of rainfall occurrence (year)
Stage A	1.5 (not analyzed for this report)
Stage B	5 (not analyzed for this report)
Stage C	50 (analyzed)
Stage D	Standard project storm rainfall (not analyzed for this report)

75. DESIGN OF PUMPING STATIONS

The design of pumping stations and interceptor pipes is based on chart 2 for class II urban areas, as shown in table B-9.

Table B-9 - Rainfall frequencies coincidental with river stage equal to design sump level for pump activation

Interior drainage section	Name of pumping station	Percent of time river stage exceeds sump level for pump activation	Class of urban development	Frequency of rainfall occurrence (years)
1	Chaska Creek	5.0(1)	II	2.5
2	Elm Street	5.0(1)	II	2.5
3	Maple Street	5.0(1)	II	2.5
4	East Creek	3.0(2)	II	1.4

(1) Reference stage-duration curve, Minnesota River, mile 29.6 (plate B-7).
(2) Reference stage-duration curve, Minnesota River, mile 28.1 (plate B-6).

76. RAINFALL DATA

The 1/2-, 1-, 6-, 24-, 48-, 96-, and 168-hour duration rainfall depths for the coincidental 1.0-year, 1.4-year, and 2.5-year and for gravity flow conditions, the 50-year frequency rains in the Chaska area were obtained from National Weather Service Technical Reports Nos. 40 and 49, Rainfall Atlas of the United States. Rainfall depth-duration-frequency relations were determined from these data in accordance with EM 1110-2-1410 as shown on plates B-8 and B-9.

77. RUNOFF CRITERIA FOR LARGE AREAS

Hypothetical hyetographs of rainfall excess were determined for each area and for each frequency of rainfall using the method described in appendix C of EM 1110-02-1410. The total loss rates used in computing the hypothetical hyetographs for the coincidental and the 50-year frequency rainfalls were based on about the same percentage of runoff for each rainstorm covering ponding stage C for this report. The runoff from rainfall frequencies to determine ponding stages A, B, and standard project storm, stage D, was not analyzed for this report but will be investigated during postauthorization studies. Runoff hydrographs were computed for each section and each rainfall frequency by application of the hypothetical hyetographs of rainfall excess to the unit hydrographs for each area. Unit hydrographs were computed using summation hydrographs (S curves) and lag relations for each area. Summation hydrographs were computed from the overland flow equation given in TM5-820-1 as follows:

$$q = r_e \tanh^2 0.922\, t\, (r_e/nL)^{0.50}\, S^{\,0.25}$$

where:

q = rate of overland flow in cfs per acre

r_e = rate of rainfall excess in inches per hour

tanh = hyperbolic tangent

t = time in minutes after start of rainfall

n = retardance coefficient

L = effective length of drainage path in feet

S = effective slope of drainage path in feet per foot.

Table B-10 defines the retardance coefficients, slopes, and lengths of the various drainage sections and data used to compute the unit hydrographs and runoff hydrographs.

Table B-10 - Summary of data for unit hydrograph computations and total runoff hydrographs

Item	Section 1		Section 2		Section 3		Section 4	
Length of drainage path (feet)	2,600		4,000		2,000		12,400	
Retardance coefficient (average n)	0.09		0.08		0.08		0.17	
Slope (average in percent)	0.77		0.75		1.50		1.62	
Length adjusted for n = .01 and S = 1.0 percent	800		900		300		4,000	
r_e = rainfall excess (inches per hour)	1.0		1.0		1.0		1.0	
Lag of S-curves (minutes)	20		20		20		60	
Time to peak of unit hydrograph (in minutes)	40		30		30		120	
Drainage area (acres)	36		52		58		1,070	
Unit hydrograph peak discharge (cfs)	41		95		91		442	
Coincidental rainfall frequency (events per 100 years)	40		40		40		70	
	C(1)	50-year	C(1)	50-year	C(1)	50-year	C(1)	50-year
Total 96-hour rainfall (inches)	4.20	7.40	4.20	7.40	4.20	7.40	3.70	7.40
Maximum rainfall for interval use (inches)	1.05	1.90	1.05	1.90	1.05	1.90	1.30	1.90
Maximum infiltration rate (inches per hour)	0.03	0.04	0.02	0.04	0.02	0.04	0.02	0.04
Total 96-hour rainfall excess (inches)	2.81	4.86	2.81	4.86	2.81	4.86	2.49	4.86
Runoff as percent of total rainfall	67	66	67	66	67	66	67	66
Maximum rainfall excess for interval use (inches)	1.03	1.86	1.03	1.86	1.03	1.86	1.28	1.86
Hydrograph peak discharge (cfs)	52	87	107	185	109	185	642	1,136

(1) "C" refers to coincidental rainfall frequencies.

78. RUNOFF CRITERIA FOR SUBAREAS

For subareas larger than 7 acres where hydrographs were not computed, the following equation was used to determine peak discharges:

$$Qs = (As/A^{0.6}Q)$$

where:

Qs = peak discharge of subarea

As = size of subarea in acres

A = size of area for which hydrograph was computed

Q = peak discharge of hydrograph for area including subarea

For areas smaller than 7 acres the rational formula used to compute the peak discharges is as follows:

$$Q = C\ (I-F)\ A$$

where:

Q = peak runoff in cfs

C = a coefficient expressing the percentage to which the peak runoff rate is reduced owing to transitory storage that appears as runoff

I = rainfall intensity in inches per hour for the most critical time of concentration during the design rainfall frequency used

F = infiltration rate in inches per hour

A = area of drainage in acres

A constant C-value of 0.7 was used for both the 50-year frequency and coincidental rainstorm runoff.

79. SEEPAGE

Estimates of seepage are shown in table B-11. The seepage values were assumed to be the peak rates of triangular-shaped seepage hydrographs having a base length equal to the assumed duration of the flood. Detailed seepage analysis will be made during postauthorization studies.

Table B-11 - Peak seepage rates

Section	Total seepage (gpm)
1	1,400
2	25,000
3	25,000
4	7,200

80. INTERCEPTORS, DITCHES AND OUTLETS

Culverts, ditches, storm drains, and outlets have been designed using procedures outlined in EM 1110-345-283 and TM5-820-4, and are discussed in the following subparagraphs.

a. Interceptors. - The hydraulic design of interceptor pipes has been based on Manning's formula using "n" values of 0.012 for concrete pipe and 0.024 for corrugated-metal pipe. Pipe sizes have been selected to maintain water surface elevations below the various damage stages outlined in EM 1110-2-1410 and to keep the hydraulic grade line at or near the flow line of the existing gravity outlets located on Elm Street and near Maple Street. The flow line of the existing outlets was estimated to be near the crown and hydraulic grade line of a future storm sewer system in Chaska. A detailed analysis of storm sewer, crown elevations, gravity outlet elevations, and hydraulic grade lines will be made during postauthorization studies. For peak discharge rates, some pipes will be under slight pressure heads. Inlet grates will be designed for safety against plugging by increasing inlet sizes by 50 to 75 percent.

b. Ditches. - The hydraulic design of ditches will be based on Manning's formula using "n" values of from 0.04 to 0.06 for grass-covered ditches having 1 on 3 side slopes. Ditch widths and bottom slopes will be selected to maintain freeboard above the design water surface profile and to maintain velocities below 5 fps. For ease in maintenance, ditch widths will not be less than 2 feet. Minimum ditch slopes of 0.3 percent will be maintained where practicable. A slope of 0.3 percent is about the minimum ditch slope that will maintain positive drainage without requiring extensive annual maintenance.

c. <u>Culverts and outlets.</u> - The hydraulic design of culverts and outlets has been based on Manning's formula and nomographs shown in reference m. and n., as listed in paragraph 73 and in TM5-820-4. Manning's "n" value of 0.012 was used for reinforced-concrete pipe. The culverts and outlets will be furnished with end sections and safety guards at inlet and outlet ends to improve safety and reduce debris deposition in pipes. Service gates and supplemental emergency gates on outlets will be selected in accordance with paragraphs 4-08 and 4-09 and chart 3 of EM 1110-2-1410.

81. PUMPING STATION REQUIREMENTS AND DESIGN

Capacities for pumping stations in the areas of sections 1 through 4 were determined by computations of peak discharge from the coincidental rainfall. Capacities for the pumping station in section 4 where ponding areas will be used have been determined from runoff coincidental with a river stage equal to design sump level for pump activation. Seepage has been assumed to start when the river stage is at the design sump level for pump activation. Runoff from the coincidental rainfall has been combined with the seepage to obtain the most critical pumping rates and/or ponding stages for the low river-stage design condition. Peak seepage, however, will not coincide with peak runoff. For initial stage pumping conditions, pumping station capacities will include runoff from coincidental rainfall and seepage assuming one third of the peak seepage rate at the design flood stage will occur at the peak rate of the coincidental rainfall runoff. Pond drawdown to elevations below design sump level for pump activation to provide additional ponding capacities during the coincidental rain will be considered in the area of section 4. Required pumping rates at high river stage have been determined to be 0.7 times the capacity determined at low-river stage, in accordance with EM 1110-2-1410, plus seepage. Since all pumping stations will discharge over the top of the flood barrier, the pumping head for each station is approximately constant for any river stage. The required maximum pumping rates will be either at initial stage for pump activation or at maximum river stage. Table B-12 will show an estimate of minimum and maximum stage pumping capacity requirements including ponding areas considered in section 4. Pumping station designs will be developed in accordance with references d, e, and f listed in paragraph 73. Minimum pumping station dimensions and station layout will be determined according to the sump dimension chart for proper flow conditions given in the Hydraulic Institute Standards, reference r in paragraph 73. Pumping station cost curves were used to derive pumping station costs for this report.

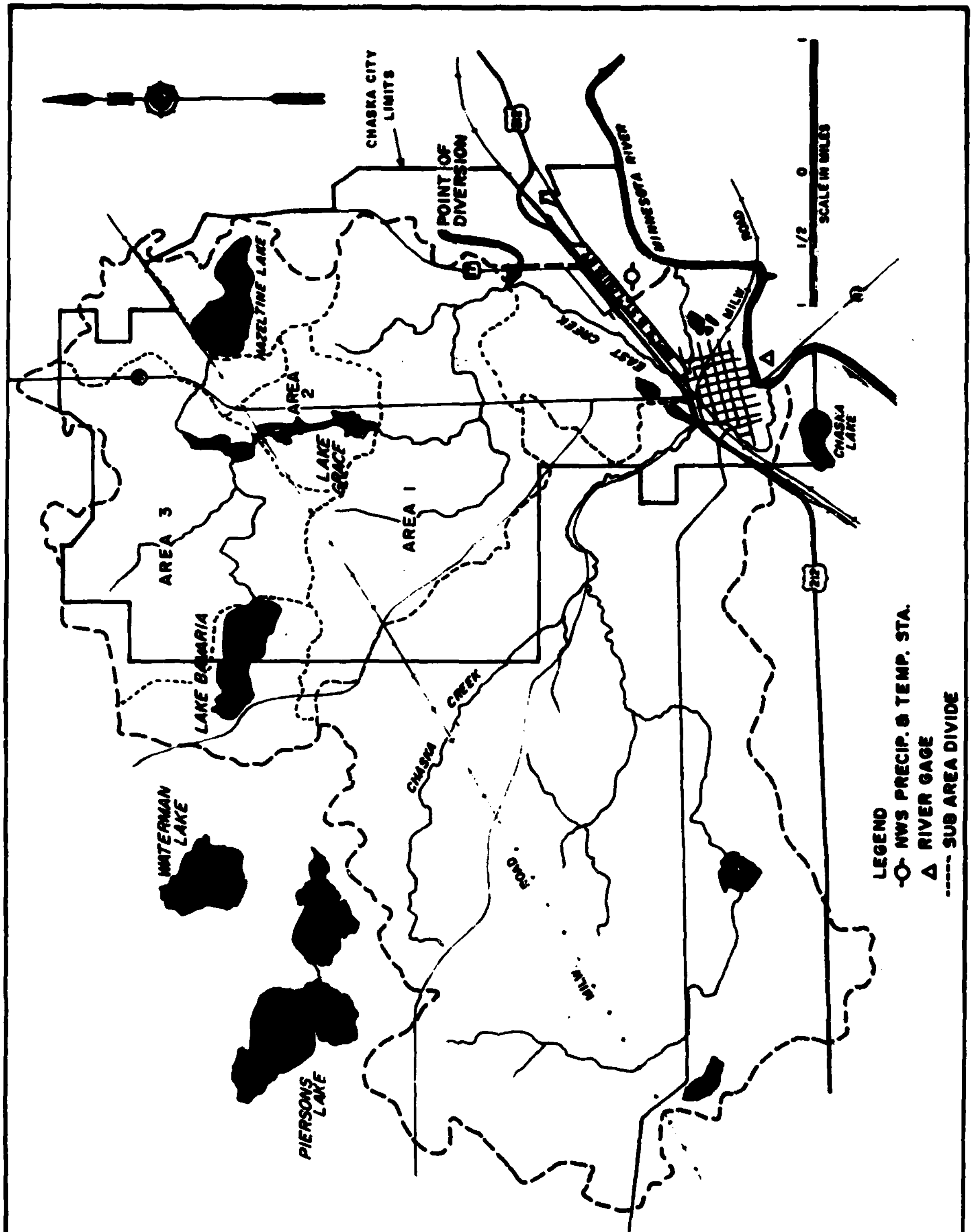
TABLE B-12 - PRELIMINARY DESIGN DATA FOR PUMPING STATIONS

Section Number	Name of Pumping Station	Drainage Area (1) (Acres)	Urban Class of Protected Area	Outlet Gate Closure for Pump Activation (Ft. MSL)	Peak Rate of Rain-fall runoff with no Ponding (gpm)	Seepage Rate when Peak Run-off Occurs (2) (gpm)	Maximum Seepage Rate at Design Stage (gpm)	0.7 Times Peak Rate of Rainfall with no Ponding Plus Max. Seepage Rate (3) (gpm)	Estimated Ponding Area (Acre-Ft.)	Pumping Rate Required to Meet Chart D-2 Criteria with no Ponding (gpm)	Pumping Rate Selected for this Report Including Ponding when Applicable (gpm)
1	Chaska Creek	36	II	705.0	23,300	500	1,400	17,700	0	23,800	23,800
2	Elm Street	52	II	705.0	45,100	8,300	25,000	56,600	0	53,400	56,600
3	Maple Street	58	II	705.0	48,900	8,300	25,000	59,200	0	57,200	59,200
4	East Creek	1,070	II	706.0	288,000	2,400	7,200	208,800	120	290,400	84,000

(1) Drainage area sections and pumping station locations are shown on Plate B-5.

(2) Estimated at 1/3 of maximum seepage when initial peak runoff occurs.

(3) 0.7 times peak rate of rainfall runoff plus maximum seepage rate controls pumping rate.



INTERIM SURVEY - FLOOD CONTROL

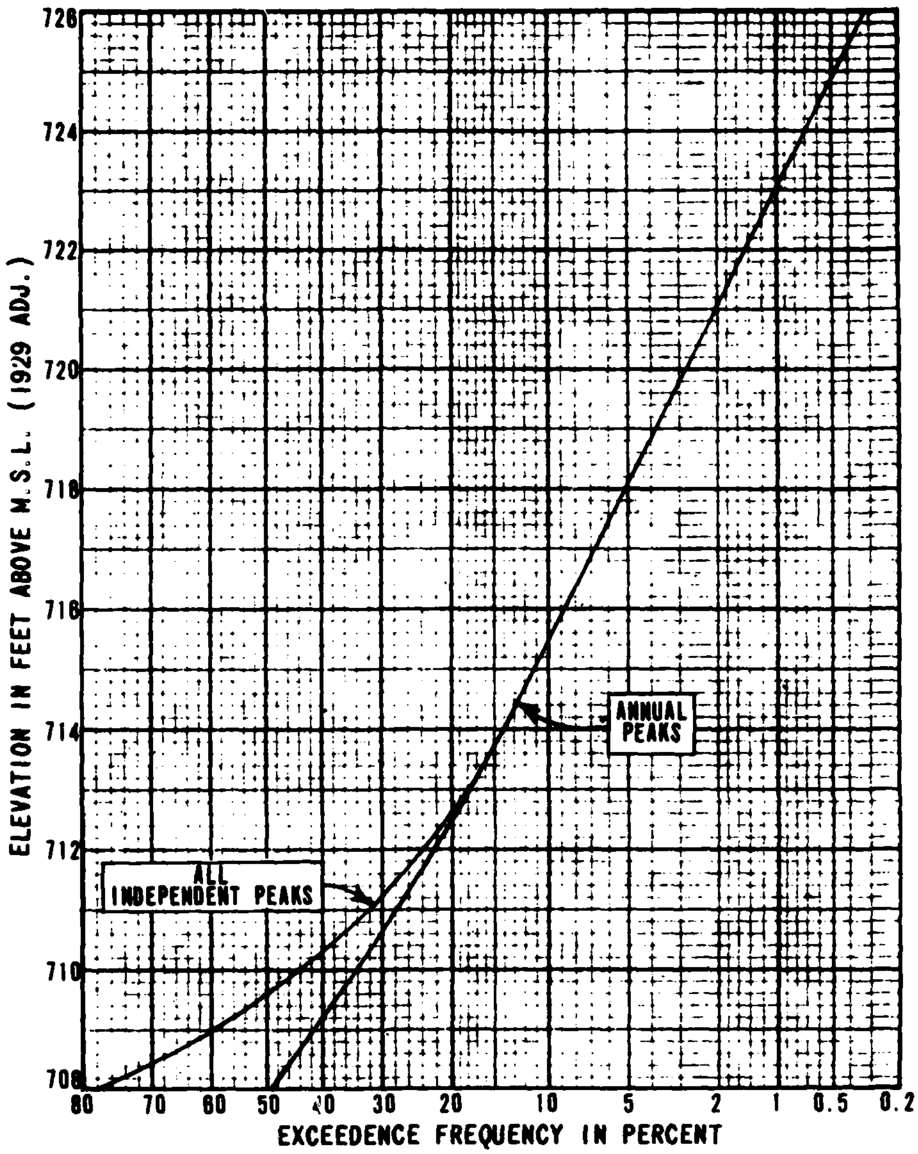
MINNESOTA RIVER AT CHASKA MINNESOTA

BASIN MAP

ST. PAUL. MINN DISTRICT

FILE NO. M34-CH-R-7/11

PLATE B-1

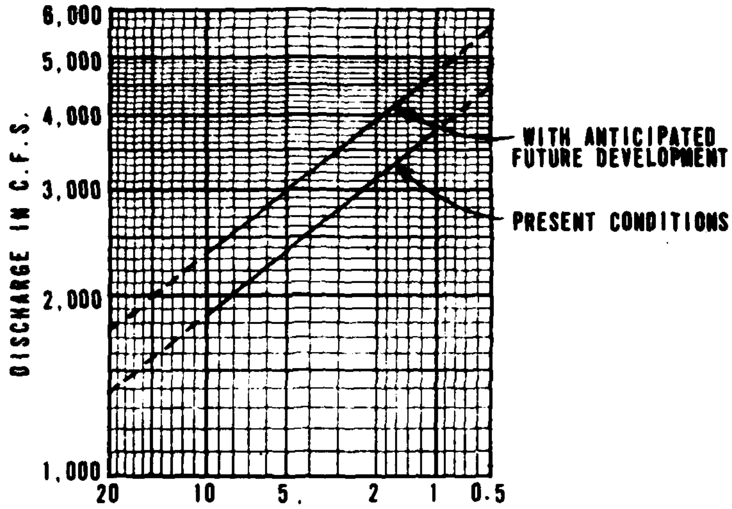


INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINN.

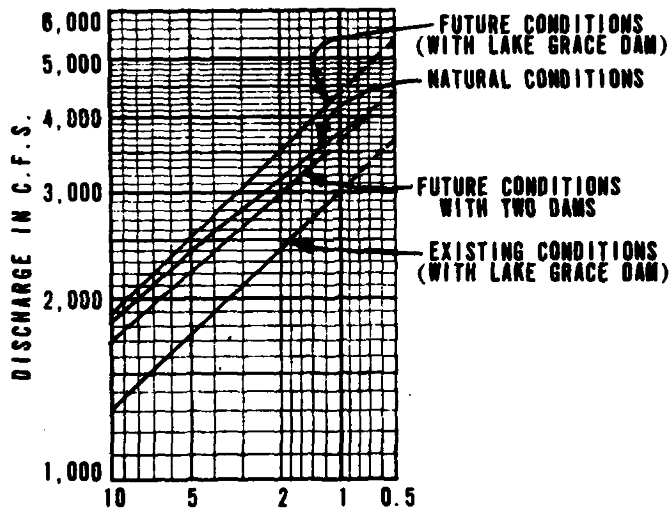
ELEVATION - FREQUENCY CURVES
MINNESOTA RIVER AT CHASKA, MINN.

ST. PAUL, MINN. DISTRICT

FILE NO. M34-CH-R-7/12



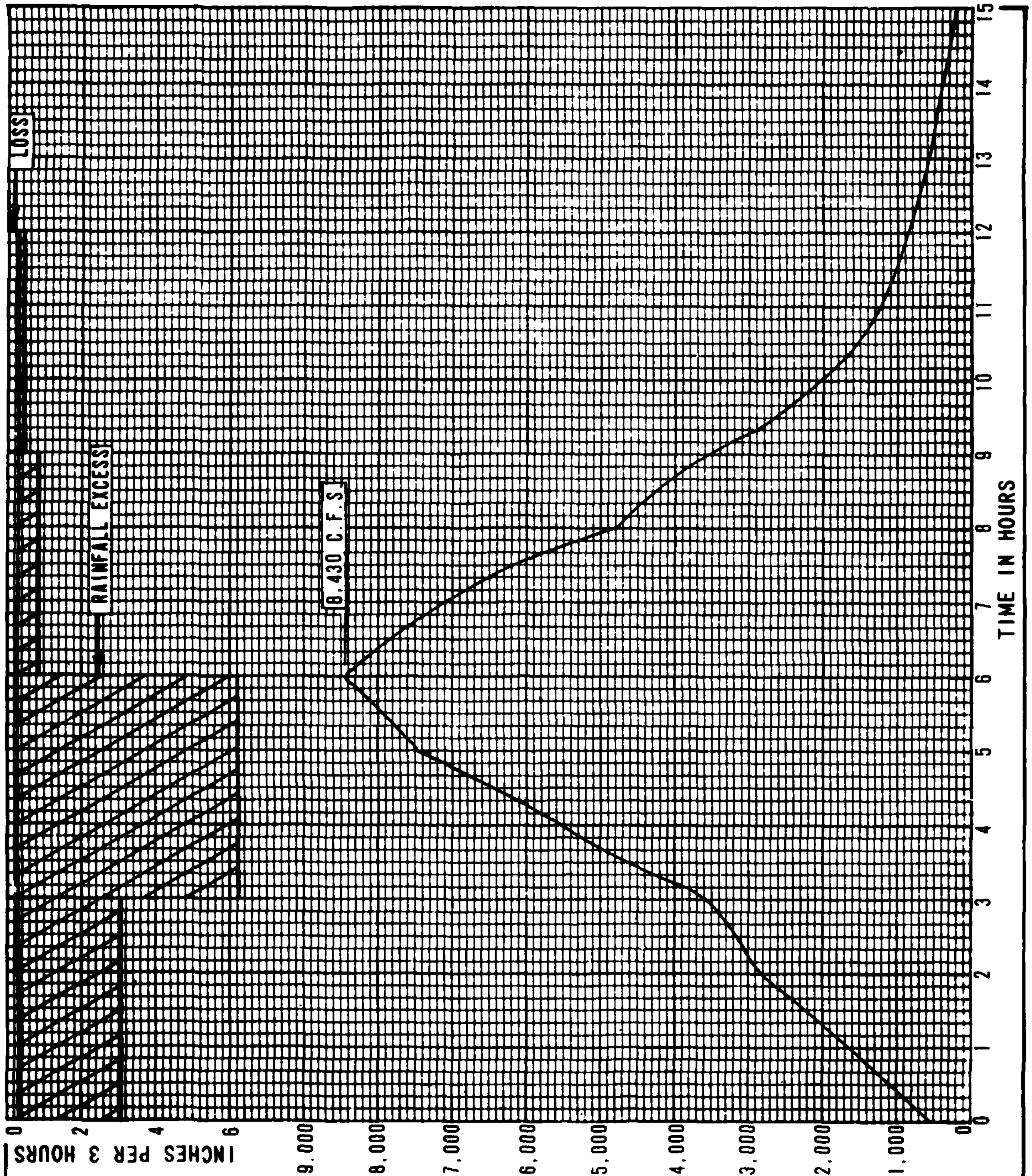
CHASKA CREEK AT FIRST STREET BRIDGE, CHASKA, MINNESOTA



EAST CREEK AT PROPOSED POINT OF DIVERSION

INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
DISCHARGE - FREQUENCY CURVES
ST. PAUL, MINN. DISTRICT
FILE NO. M34-CH-R-7/13

PLATE B-3



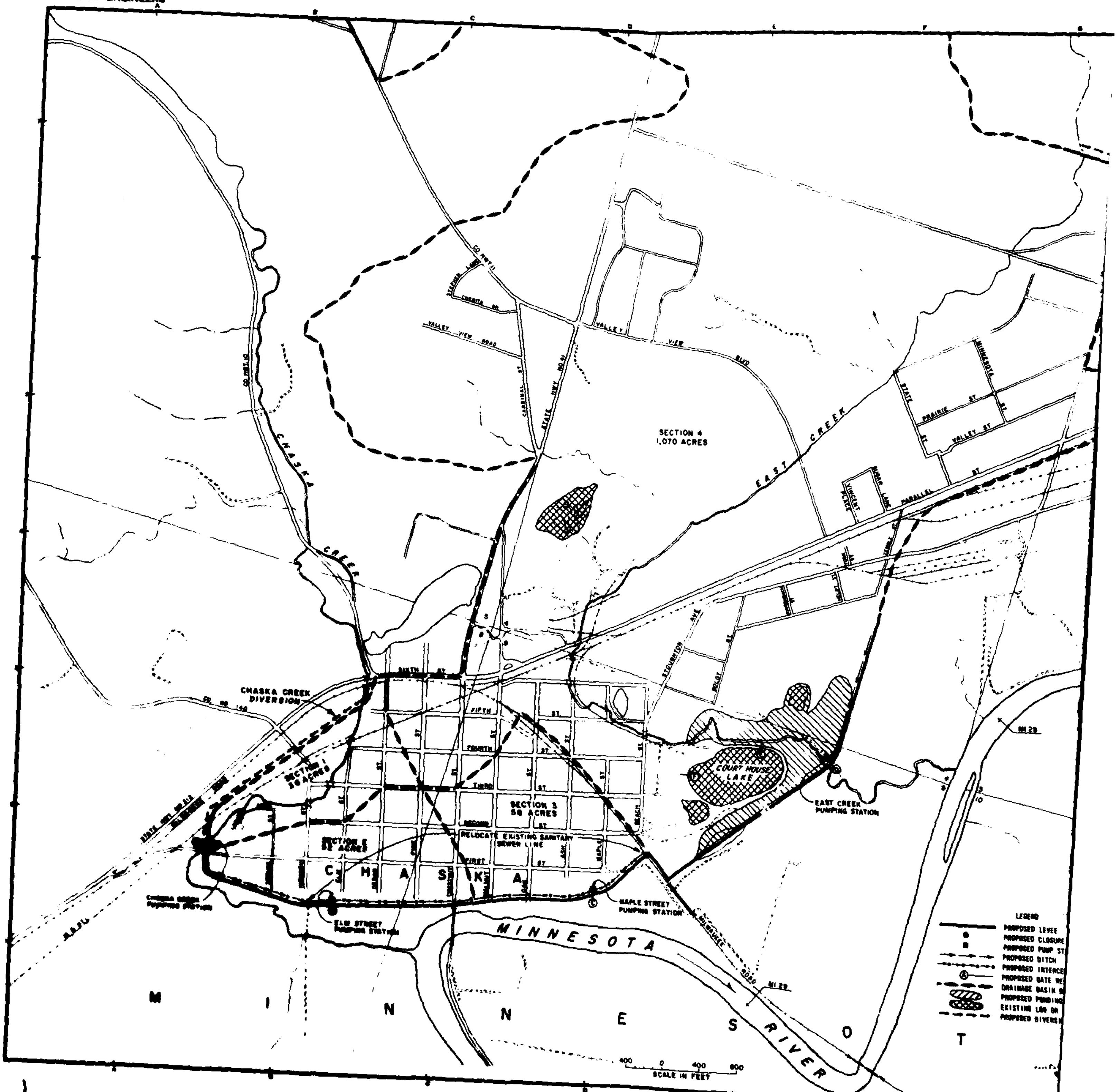
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA

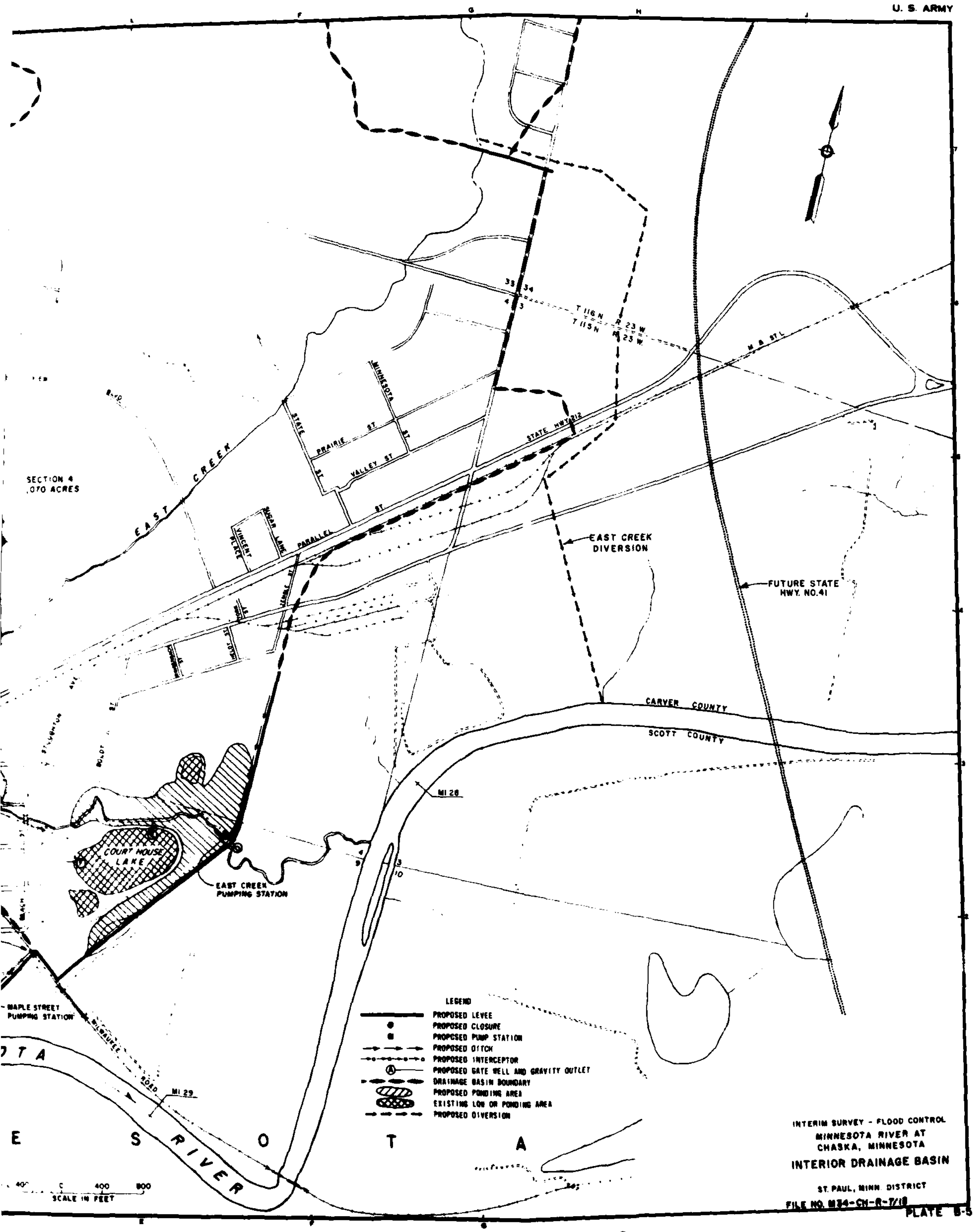
STANDARD PROJECT FLOOD
EAST CREEK AT PROPOSED
POINT OF DIVERSION

ST. PAUL, MINN. DISTRICT

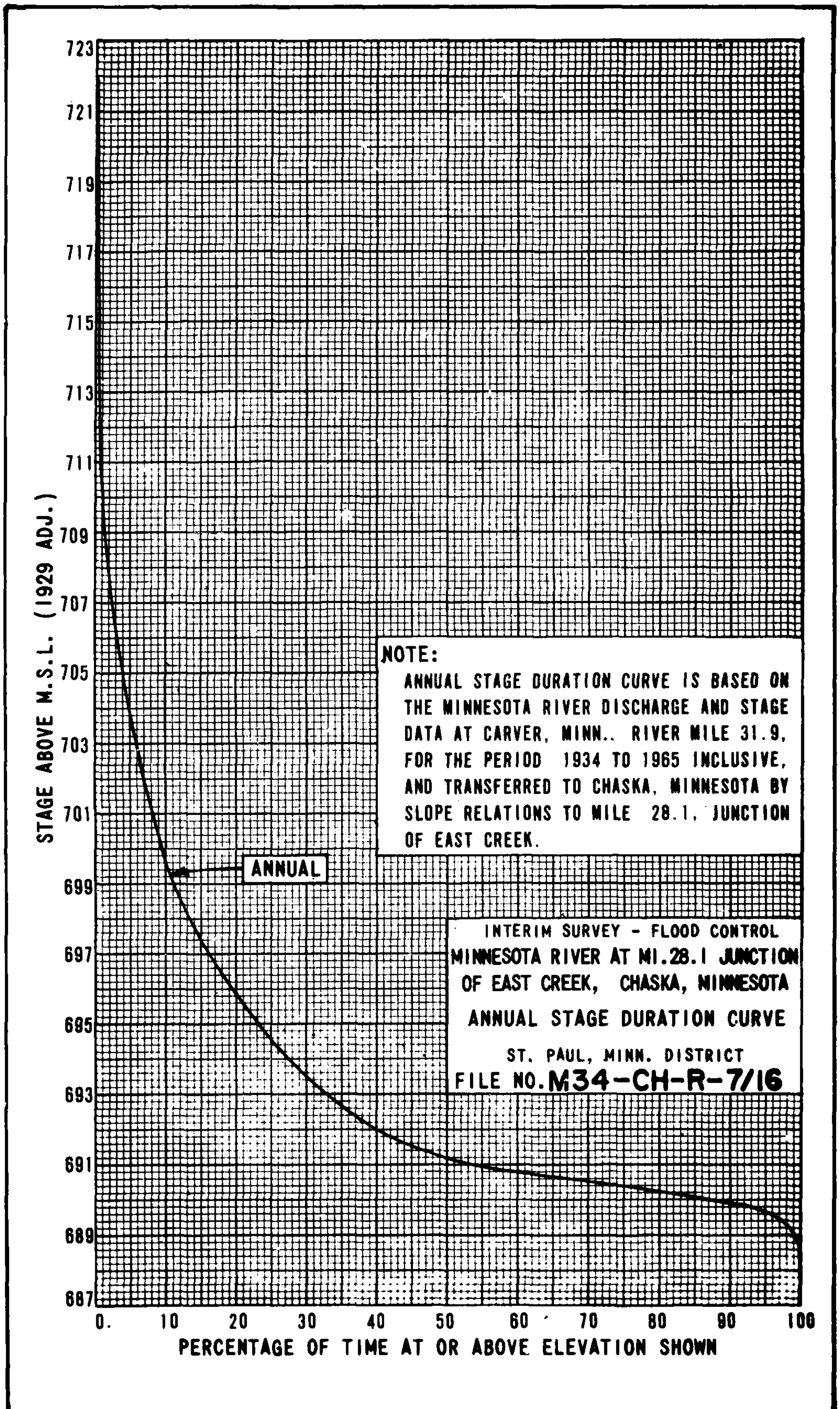
FILE NO. **M34-CH-R-7/14**

CORPS OF ENGINEERS




U. S. ARMY
EAST CREEK
SECTION 4
EAST CREEK DIVERSION
FUTURE STATE HWY. NO. 41
STATE HWY 212
PRAIRIE ST
VALLEY ST
PARALLEL ST
MINNESOTA ST
T 116 N R 23 W
T 115 N R 23 W
CARVER COUNTY
SCOTT COUNTY
MI 28
MI 29
COURT HOUSE LAKE
EAST CREEK PUMPING STATION
MAPLE STREET PUMPING STATION
E S O T A
RIVER
SCALE IN FEET
LEGEND
PROPOSED LEVEE
PROPOSED CLOSURE
PROPOSED PUMP STATION
PROPOSED DITCH
PROPOSED INTERCEPTOR
PROPOSED GATE WELL AND GRAVITY OUTLET
DRAINAGE BASIN BOUNDARY
PROPOSED PONDING AREA
EXISTING LOW OR PONDING AREA
PROPOSED DIVERSION
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
INTERIOR DRAINAGE BASIN
ST. PAUL, MINN. DISTRICT
FILE NO. M34-CH-R-7/18
PLATE B-5

2



723
721
719
717
715
713
711
709
707
705
703
701
699
697
695
693
691
689
687
STAGE ABOVE M.S.L. (1929 ADJ.)
0. 10 20 30 40 50 60 70 80 90 100
PERCENTAGE OF TIME AT OR ABOVE ELEVATION SHOWN
ANNUAL
NOTE:
ANNUAL STAGE DURATION CURVE IS BASED ON THE MINNESOTA RIVER DISCHARGE AND STAGE DATA AT CARVER, MINN., RIVER MILE 31.9, FOR THE PERIOD 1934 TO 1965 INCLUSIVE, AND TRANSFERRED TO CHASKA, MINNESOTA BY SLOPE RELATIONS TO MILE 28.1, JUNCTION OF EAST CREEK.
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT MI.28.1 JUNCTION OF EAST CREEK, CHASKA, MINNESOTA
ANNUAL STAGE DURATION CURVE
ST. PAUL, MINN. DISTRICT
FILE NO. M34-CH-R-7/16

PLATE B-6

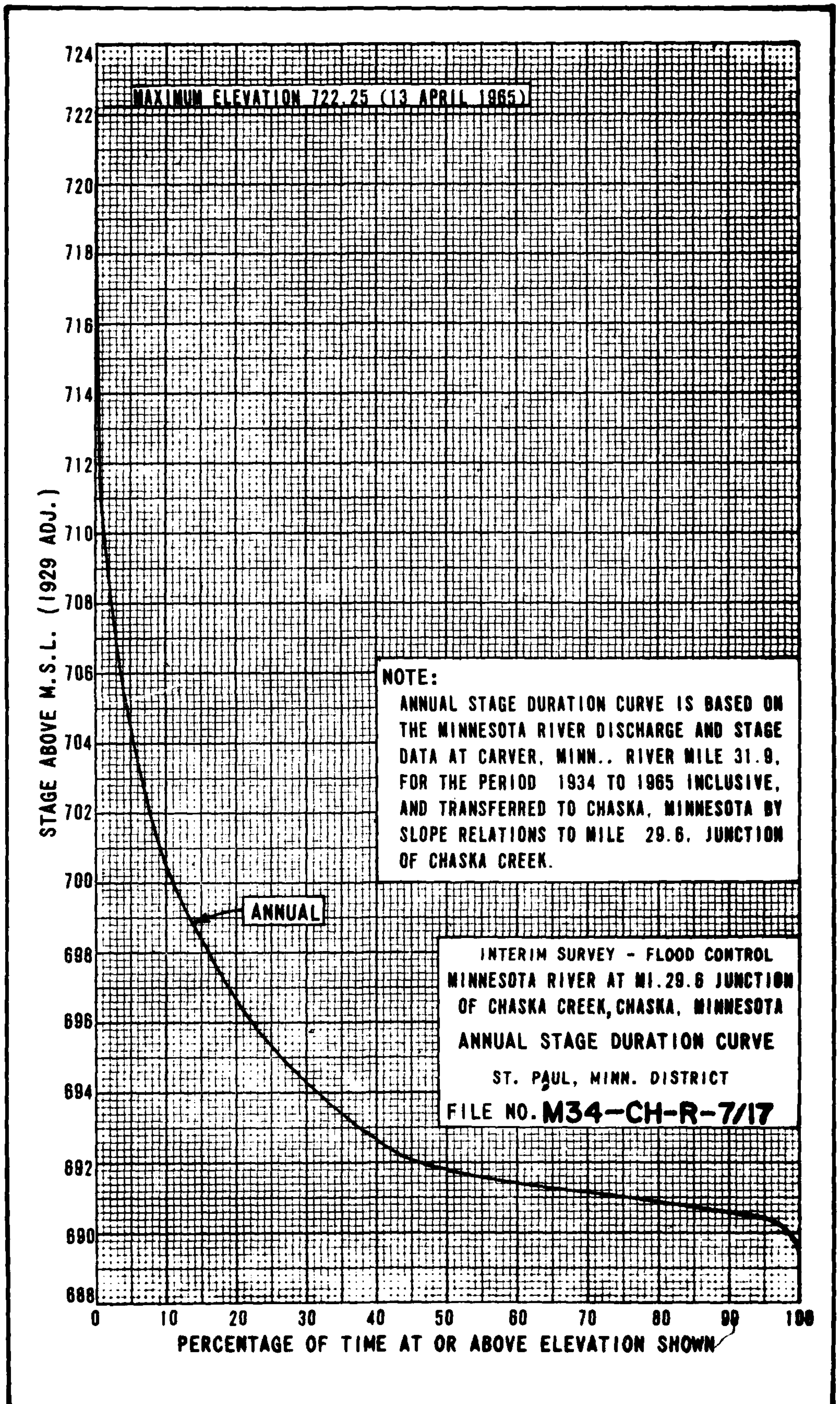
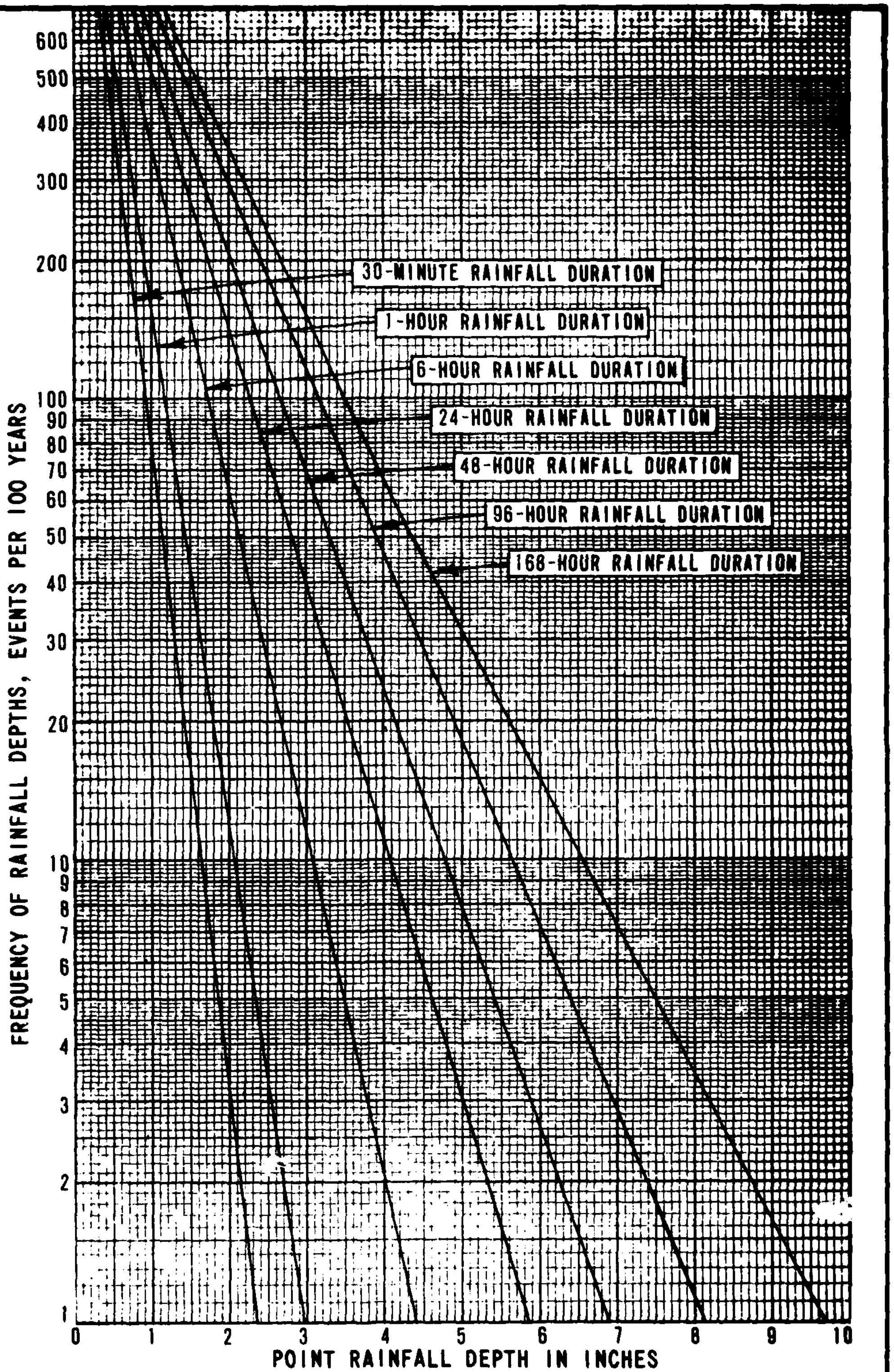

MAXIMUM ELEVATION 722.25 (13 APRIL 1965)
724
722
720
718
716
714
712
710
708
706
704
702
700
698
696
694
692
690
688
STAGE ABOVE M.S.L. (1929 ADJ.)
NOTE:
ANNUAL STAGE DURATION CURVE IS BASED ON THE MINNESOTA RIVER DISCHARGE AND STAGE DATA AT CARVER, MINN., RIVER MILE 31.9, FOR THE PERIOD 1934 TO 1965 INCLUSIVE, AND TRANSFERRED TO CHASKA, MINNESOTA BY SLOPE RELATIONS TO MILE 29.6, JUNCTION OF CHASKA CREEK.
ANNUAL
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT MI.29.6 JUNCTION OF CHASKA CREEK, CHASKA, MINNESOTA
ANNUAL STAGE DURATION CURVE
ST. PAUL, MINN. DISTRICT
FILE NO. M34-CH-R-7/17
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF TIME AT OR ABOVE ELEVATION SHOWN

PLATE B-7

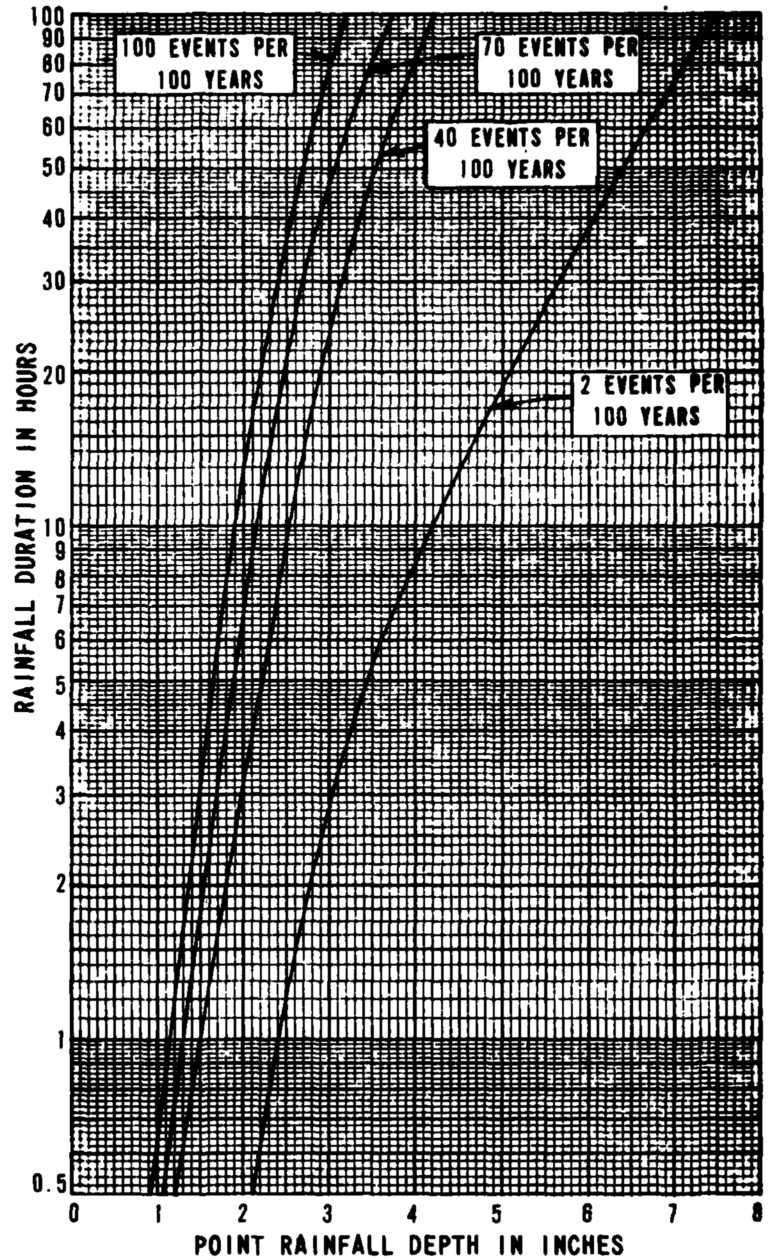


INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA

POINT RAINFALL CURVES

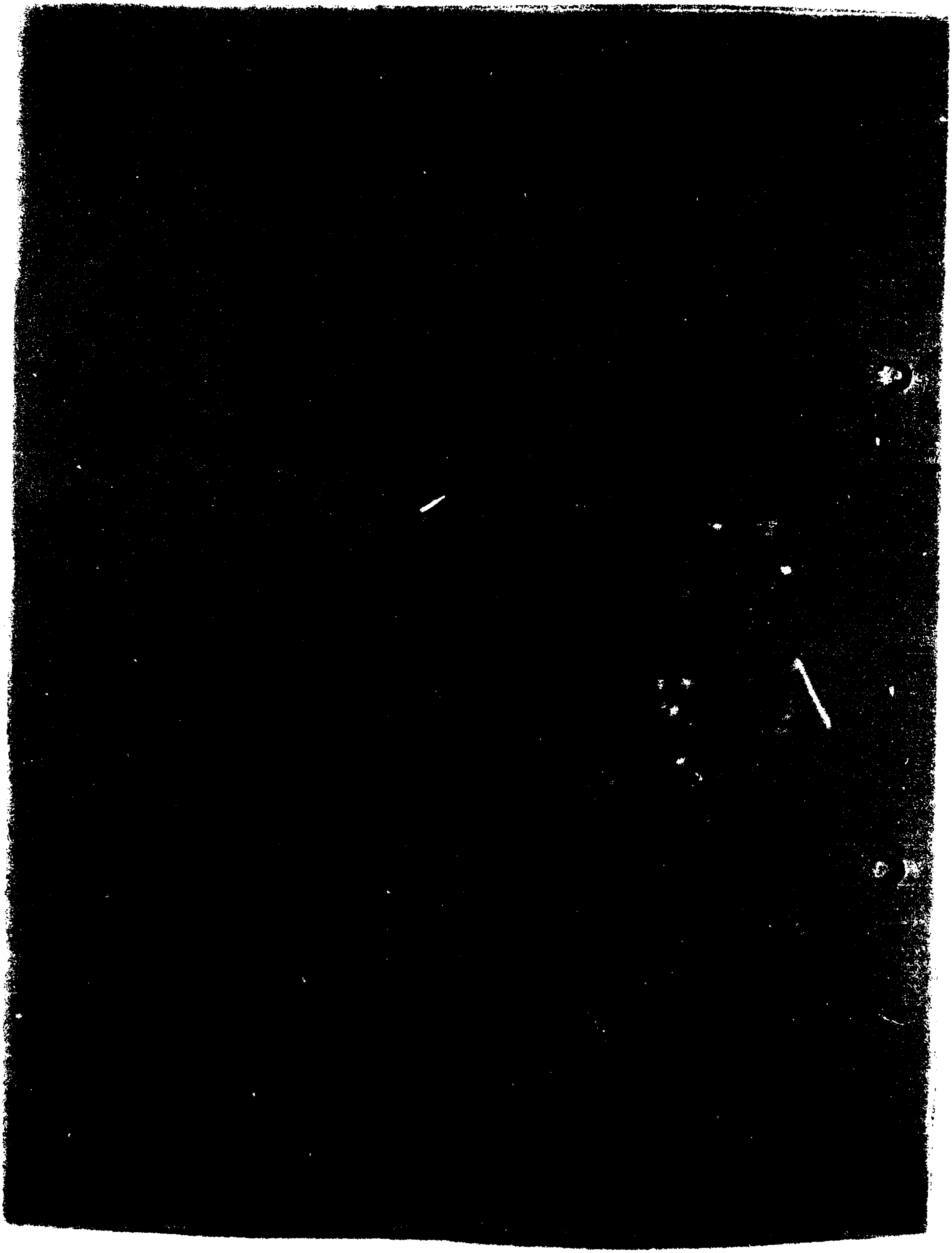
ST. PAUL, MINN. DISTRICT

FILE NO. M34-CH-R-7/18



INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
POINT RAINFALL CURVES
ST. PAUL, MINN. DISTRICT
FILE NO. M34-CH-R-7/19

PLATE B-9



APPENDIX C

FLOOD DAMAGE AND BENEFIT ANALYSES AND PLAN FORMULATION

PURPOSE AND SCOPE

1. This appendix presents the economic aspects of flooding in the Chaska area, the selection of a comprehensive water resources management plan, and the determination of the scale of development for that plan. Following a brief description of the city, including its flood characteristics, an economic base study outlining historic and projected economic development, population, employment and per capita income trends and a land-use study are presented. The appendix then discusses the procedural analysis used to determine monetary flood damages at Chaska, both with and without proposed flood control improvements and under present and future conditions, including allowances for future economic growth. Economic data gathered from field surveys; "Jonathan, A Planning Description," prepared by the Jonathan Development Corporation, Chaska, Minn., February 1971; and "Report on Comprehensive Sewer Study for Chaska, Minnesota, 1972," prepared by Bonestroo, Rosene, Anderlik and Associates, Incorporated, provided principal sources of information for the economic study. The analysis is based on an assumed economic life of 100 years, the current Federal discount rate of 5 5/8 percent, and price levels prevailing in February 1973. Following the economic analysis, various practicable water resource management plans are evaluated and compared based upon economic development, social acceptability, and environmental quality. The plan which best fulfills these objectives is selected and formulated to the optimum scale of project development.

LOCATION AND DESCRIPTION OF CHASKA AREA

2. The city of Chaska is located in Carver County, Minn., on the left bank (north side) of the Minnesota River (mile 29.6) about 20 miles southwest of Minneapolis, Minn. Over 50 percent of the existing residential, commercial, and industrial developments in the city are located in the floodplain. At Chaska, the Minnesota River drains an area of about 16,600 square miles. Chaska Creek, with a drainage area of about 15 square miles, flows through the west end of the city;and an unnamed creek, with a drainage area of about 11.8 square miles, flows through the northeast side of the city. For this report, the latter stream is referred to as East Creek.

3. Chaska has experienced flooding frequently from high stages on the Minnesota River and flash flooding from East and Chaska Creeks. Overflow from either or both of the creeks could pond behind the existing levee and cause flood damages. Also, recent residential and commercial developments have been encroaching into the overflow area of East Creek in a terrace along the Minnesota River floodplain upstream from the leveed area. High flows on East Creek could cause extensive property damage and possible loss of life in this terrace area. The history of floods at Chaska is discussed in the main report and in appendix B.

4. At Chaska, about 540 residences, 47 businesses and industries, and two public buildings would be directly affected by flooding of the two creeks and the Minnesota River. Damages estimated at $4.0 million would result from an intermediate regional flood (1-percent chance flood) under present conditions. Emergency levees constructed along the Minnesota River in 1965 and raised in 1969 provide Chaska with about a 7-percent degree of flood protection (excluding seepage problems) from the Minnesota River but offer no protection from flooding on Chaska and East Creeks. Also, the interior drainage facilities are not adequate to handle interior drainage and seepage through the levee system.

5. Chaska is one of the oldest communities in Minnesota, dating back to 1854. Early growth was closely linked with the Minnesota River and the town quickly became an important port. Later the river channel became silted and unnavigable and Chaska ceased to grow. From 1890 to 1950, the population of Chaska remained stable at approximately 2,000. The population began to increase after 1950 and reached 4,352 persons in 1970. Part of the increase has been due to large annexations by the city. The Hazeltine area was annexed in 1963 and the Jonathan area was added in 1967, bringing the city to its present size of 9,640 acres. The city of Chaska extends 5.5 miles north from the Minnesota River and 3 miles east and west. For the most part, the annexed areas are still semirural, but are in the path of major urban growth patterns of the Twin Cities metropolitan area. Areas along the western boundary of the present city limits may be annexed in the future.

6. In the portion of Chaska near the Minnesota River, the land is relatively flat. The soils vary from sands to clays. Approximately 1 mile north of the river is an area of very steep hills and bluffs running in a southwest-northeast direction. The bluffs range from 75 feet to 100 feet in height. East and Chaska Creeks flow out of deeply eroded ravines in these bluffs. North and west of these bluffs are rolling slopes with many lakes, marshes, and peat bogs.

7. Minnesota Highways 212, 41, 101, and 5 serve Chaska and, together with a network of good county roads, provide excellent highway transportation. Air transportation is provided at nearby Eden Prairie, Minn., with facilities for private planes; and commercial flights are available at the Minneapolis-St. Paul International Airport. Rail service is provided by the Milwaukee Road railroad and the Chicago and North Western Railway.

ECONOMIC BASE

8. ECONOMIC DEVELOPMENT

The earliest economic activity in the vicinity of Chaska consisted of a trading post operated by agents of American fur companies. In 1854 the Chaska townsite was surveyed and platted, and Carver County was created in 1855. By 1860, many steamboats traveled on the Minnesota River. In some seasons they made as many as 400 trips between St. Paul and Mankato, Minn., usually with stops at Chaska. However, the river traffic started to decline in importance after 1862 and eventually ceased. The economic base of the town changed from river transportation to the agricultural development of the hinterland. Rail transportation permitted rapid expansion of Chaska during the 1870's and the 1880's, and Chaska reached its peak about 1890. Population was essentially unchanged for six decades from 1890 to 1950. Since 1950, Chaska has been growing again. Significant future growth appears to be related mainly to the further development of the new community of Jonathan, which is located on largely undeveloped land within the city limits of Chaska. Jonathan is conceived as a multipurpose community which will eventually provide housing, employment, and services for 50,000 people on an 8,000-acre site. Chaska provides water, fire, and police protection and other municipal services to Jonathan. The Jonathan site is mainly within the northern half of the city limits of Chaska. Future growth in Jonathan is related to the growth of the Minneapolis-St. Paul metropolitan area. The population of the Minneapolis-St. Paul Standard Metropolitan Statistical Area (SMSA) was 1,813,647 in 1970. Generally, a city such as Chaska, which is located 20 miles from a regional growth center, has better prospects for long-range economic growth than communities located farther away from growth centers. The old part of Chaska has the characteristics of a small town, while newer areas have the characteristics of suburbia.

9. POPULATION

The population of Chaska increased from 2,501 in 1960 to 4,352 in 1970 (table C-1). However, several annexations occurred during this period. The 1970 population was 2,902 in the area included in the 1960 census; and areas annexed after 1960 added 1,450 persons to the 1970 population. During the 1940-1950 decade, the percentage increases in population for Chaska, Carver County, and the State of Minnesota were less than the average for the United States (table C-2). However, the percentage increase in population for Chaska exceeded the average for the United States during the 1950-1960 and 1960-1970 decades. The percentage increase in population for Carver County exceeded the average for the United States during the past decade.

Table C-1 - Historic and projected population, 1940-2030

Area	Historic				Projected					
	1940	1950	1960	1970	1980	1990	2000	2010	2020	2030
United States (1)	132,164,569	151,325,798	179,323,175	203,211,926	234,193,000	269,796,000	306,757,000	348,897,000	397,562,000	
Minneapolis- St. Paul OBE economic area (2)	1,788,890	1,979,397	2,354,129	2,831,618	3,185,300	3,695,000	4,231,000	4,842,700	5,543,200	6,243,700 (3)
Carver County (4)	17,606	18,155	21,358	26,310	53,919	93,195	114,271	-	-	-
Chaska (5) (including Jonathan)	1,927	2,008	2,50[illegible]	4,352	27,800	63,000	80,000	-	-	-

(1) U.S. Department of Commerce. Bureau of the Census.
(2) Office of Business Economics, U.S. Department of Commerce, 1968.
(3) Extrapolated.
(4) Projected values from data furnished in (2) and (5).
(5) Bonestroo, Rosene, Anderlik and Associates, Incorporated, Consulting Engineers, St. Paul, Minn., Report on Comprehensive Sewer Study for Chaska, Minnesota, 1972.

Table C-2 - Population change, 1940-1970

Decade	United States(1) (percent)	Minnesota(1) (percent)	Carver County (percent)	Chaska (percent)
1940-1950	+14.5	+6.8	+3.1	+4.2
1950-1960	+18.7	+14.5	+17.6	+24.6
1960-1970	+13.3	+11.5	+32.5	+74.0

(1) Water Resources Research Center, University of Minnesota, A Survey of Attitudes Toward the Mississippi River as a Total Resource in Minnesota, page 12.

10. In 1971, building permits in Carver County (including Chaska)were as follows: 311 permits for single-family units, six for duplex units, 57 for townhouses, 180 for multifamily units, 81 for mobile homes, and a net loss of three units for a total of 632 units.[1] Building permits for Chaska (including Jonathan) in 1971 were 132 single family units, 26 townhouse units, 48 multifamily units, and 30 mobile home units for a total of 236 units.

11. Rapid growth of the new community of Jonathan, located within the municipal limits of Chaska, is expected to cause a rapid population increase at Chaska. Projections by a planning consultant indicate a total population for Chaska of 80,000 by the year 2000.[2] Based on an index of 1970 = 100, Chaska, including Jonathan, is expected to have an index of 1838 by the year 2000 (table C-3). Due mainly to the expected growth of Chaska, Carver County's population is projected to increase three times by the year 2000. The population of the Minneapolis-St. Paul OBE economic area (OBE economic area 06094), which includes Carver County and 43 other counties, is estimated to increase from 2,831,618 persons in 1970 to 6,243,700 in 2030.[3] Based on an index of 1970 = 100, OBE economic area 06094 is expected to have an index of 220 by the year 2030, the same rate as the average for the United States.

Table C-3 - Indexes of population change, 1970-2030

Area	1970	1980	1990	2000	2010	2020	2030
United States	100	115	133	151	172	196	220(1)
OBE area 06094	100	112	130	149	171	196	220(1)
Carver County	100	190	329	404	-	-	-
Chaska (including Jonathan)	100	639	1,448	1,838	-	-	-

(1) Extrapolated.

(1) Data-log, Metropolitan Council of the Twin Cities Area, December 1972, page 6.
(2) Bonestroo, Rosene, Anderlik and Associates, Incorporated, Report on Comprehensive Sewer Study for Chaska, Minnesota, 1972, page 20.
(3) Based on the OBERS projections by the U.S. Departments of Commerce and Agriculture for the Water Resources Council, March 1968.

12. EMPLOYMENT AND INDUSTRIES

Chaska has the largest industrial base in Carver County. Fifteen industries manufacture food products, toothpaste, building materials, and various other products. Located in the older part of Chaska are a foundry and companies which manufacture bricks and machine tools and process pickles. Chaska is also an important center of retail and wholesale trade. Civil service workers and elected public officials are relatively numerous in Chaska, mainly because the Carver County Courthouse is located in Chaska. New industries coming into Chaska are locating mainly in the Jonathan Industrial Park. Good industrial locations also exist on the Minnesota River east of the old part of Chaska.

13. Total employment in Carver County increased from 7,797 in 1960 to 11,138 in 1970, an increase of 3,341 (table C-4). Employment increased in all categories except agriculture, forestry, and fisheries. Large increases in employment occurred in manufacturing, trade, and services.

Table C-4 - Employment by industry, Carver County, Minn. 1940-1970

Industry	1940		1950		1960		1970	
	Number	Percent of total	Number	Percent of total	Number	Percent of total	Number	Percent of total
Agriculture, forestry, and fisheries	3,521	60.2	2,983	45.2	2,421	31.0	1,492	13.40
Mining	5	0.1	8	0.1	8	0.1	26	0.03
Contract construction	196	3.3	390	5.9	546	7.0	841	7.55
Manufacturing	316	5.4	827	12.6	1,520	19.5	3,166	28.52
Transportation, communication, and utilities	197	3.4	345	5.3	348	4.5	488	4.38
Trade	615	10.5	926	14.0	1,260	16.2	2,264	20.43
Finance, insurance, real estate	51	0.8	101	1.5	161	2.1	269	2.42
Services	738	12.6	780	11.8	1,205	15.4	2,369	21.27
Government	83	1.4	125	1.9	117	1.5	223	2.00
Industry not reported	131	2.3	109	1.7	211	2.7	-	-
Total	5,853	100.0	6,594	100.0	7,797	100.0	11,138	100.00

14. Total employment in Chaska grew from 859 in 1960 to 1,723 in 1970, an increase of 864 persons (table C-5). The largest gain in employment was in manufacturing, with 381 more people employed in 1970 than in 1960. Significant gains in employment occurred in all categories except agriculture, forestry, fisheries, and mining. In 1970, employment in manufacturing represented about 36 percent of total employment in the city of Chaska; wholesale and retail trade, 18 percent; and services, 15 percent.

Table C-5 - Employment by industry, Chaska, Minn., 1960-1970

Industry	1960 Number	1960 Percent of total	1970 Number	1970 Percent of total
Agriculture, forestry, fisheries	20	2.33	-	
Mining	4	0.46	-	
Construction	103	11.99	152	8.82
Manufacturing	236	27.47	617	35.81
Transportation, communication, and other public utilities	37	4.31	85	4.93
Wholesale and retail trade	236	27.47	316	18.34
Finance, insurance, and real estate	20	2.33	103	5.98
Services	123	14.32	250	14.51
Public administration	39	4.54	59	3.43
Industry not reported	41	4.78	141	8.18
Total	859	100.00	1,723	100.00

15. Total employment in OBE economic area 06094 is expected to increase from 1,063,200 in 1970 to 2,227,300 in 2020, an increase of 1,164,100 persons (table C-6). The participation rate (employment/population) in OBE economic area 06094 is expected to increase at the same rate as the average for the United States.

16. The most significant growth in employment for Chaska is expected to occur within the Jonathan unit. The Jonathan Development Corporation estimates that 18,000 new jobs will be created by year 2000. Development in the Jonathan Industrial Park adjacent to Hazeltine Lake is currently progressing ahead of schedule. Although employment in the remainder of Chaska will increase as the population expands, many residents will continue to be employed in the Twin Cities metropolitan area.

Table C-6 - Employment projections, OBE economic area 06094 and the United States (1)

	1940	1950	1960	1970	1980	1990	2000	2010	2020
Employment OBE economic area 06094	616,133	776,292	879,966	1,063,200	1,262,800	1,454,200	1,697,600	1,952,400	2,227,300
Employment United States	45,375,815	57,460,770	66,372,658	78,954,000	92,712,000	105,910,000	122,663,000	140,141,000	159,178,000
Participation rate economic area 06094 (2)	0.34	0.39	0.37	0.38	0.40	0.39	0.40	0.40	0.40
Participation rate United States	0.34	0.38	0.37	0.39	0.40	0.39	0.40	0.40	0.40

(1) Office of Business Economics, U.S. Department of Commerce, 1968.
(2) Participation rate = employment divided by population.

17 INCOME

The magnitude of income is a measure of the economic well-being of a community. Personal income is income received from all sources and is measured before deduction of income tax and other direct personal taxes. Per capita income of a community is personal income divided by population and measures the average standard of living in the community. In 1968 it was projected that total personal income for OBE economic area 06094 would reach $8,464,000 in 1970 (table C-7), expressed in 1958 dollars. Based on an index of 100 in 1970, the total personal income index for the OBE economic area 06094 is projected to be 808 in 2020. It was projected in 1968 that per capita income for the economic area would reach $3,064 in 1970 (1958 dollars). Based on an index of 100 in 1970, per capita income is estimated to be an index of 498 in the year 2030.

Table C-7 - Total personal and per capita income projections, OBE economic area 06094, 1970-2030

	1970	1980	1990	2000	2010	2020	2030
Total personal income (1958 dollars)	$8,464,000	$13,063,000	$19,697,000	$30,277,000	$45,700,000	$68,378,000	
Index	100	154	233	358	540	808	
Per capita income (1958 dollars)	3,064	4,101	5,331	7,156	9,437	12,335	
Index	100	134	174	234	308	403	498 (1)

(1) Extrapolated.
Source: OBERS projections.

18. LAND USE

The floodplain at Chaska consists of approximately 390 acres, including the areas behind the Minnesota River levee and along East and Chaska Creeks (table C-8). About 34 percent of the floodplain is used for residential purposes, 18 percent is commercial property, 7 percent is occupied by streets and railroads, and 4 percent is public property. Vacant land, located mainly along East Creek, accounts for the remaining 37 percent of the total land area in the floodplain. The vacant area along East Creek is low and may be filled in accordance with floodplain regulations for commercial or residential uses. Maps showing existing land use and future land use at Chaska are provided on plates C-1 and C-2, respectively.

Table C-8 - Land use, 100-year floodplain, East and Chaska Creeks, and behind Minnesota River levee, Chaska, Minn.

Land-use category	100-year floodplain Acres	Percent of area
Residential	131	33.6
Commercial	72	18.5
Public	14	3.6
Streets and railroads	26	6.7
Vacant	147	37.6
Total	390	100.0

19. The estimated values of structures in the floodplain of the two creeks and behind the Minnesota River levee are $11.5 million residential, $1.0 million commercial, and $2.7 million public, for a total of $15.2 million (table C-9).

Table C-9 - Estimated value of structures, 100-year floodplain, East and Chaska Creeks and behind Minnesota River levee, Chaska, Minn.

Category	Estimated value
Residential	$11,538,000
Commercial	983,000
Public	2,718,000
Total	15,239,000

EVALUATION OF FLOOD DAMAGES AND BENEFITS

20. GENERAL

Urban property in Chaska is susceptible to flood damage from East Creek, Chaska Creek, and the Minnesota River. In this economic analysis, annual flood damages have been computed for present conditions defined as conditions anticipated in 1980, when it is assumed that proposed flood control improvement would be completed and in effective operation. The "present conditions" damages include

an allowance for interim economic growth applied to the computed base year (1973) damages. This economic analysis also recognizes the flood damage potential of existing floodplain development under future projected conditions and the extent to which the various alternatives will reduce damages over an assumed period of 100-year economic life.

21. DAMAGES FROM MINNESOTA RIVER FLOODING

Chaska has sustained flood damages on numerous occasions from the Minnesota River. The most recent damages occurred in 1965 when the levee was overtopped, and damages amounted to $1.7 million in 1965 prices, or $2.5 million in 1973 prices. No overtopping of the levee occurred during the 1969 flood since the levee was raised just prior to the flood.

22. POTENTIAL FLOOD DAMAGES - EAST AND CHASKA CREEKS

Chaska is also subject to potential flooding from East and Chaska Creeks. Floodwaters from these creeks could flow through the streets of Chaska and pond behind the Minnesota River levee. Accordingly, the property subject to potential flooding from these creeks includes structures along both creeks and the entire floodplain area behind the existing Minnesota River levee system.

23. Since there have been no recent floods on East Creek and Chaska Creek, many structures have been built during the past several years on the floodplains of these creeks. Rapid development in the upland area of East Creek, particularly in the area to be occupied by the new community of Jonathan, will increase the runoff volume from the watershed. However, based on hydrologic studies, this increase in runoff volume will be partially offset by the regulation effect of Lower Lake Grace Dam which was constructed as part of the Jonathan Development. In addition, the Jonathan Development Corporation is considering the development of an Upper Lake Grace dam which would further offset the increase in runoff volume to the extent that the development would have no appreciable effect on flood conditions at Chaska.

24. FLOOD DAMAGE SURVEYS

Estimates of flood damages in Chaska are based on a detailed damage survey made in 1967 and a survey conducted in 1972 of the construction which occurred during the period 1967-1972. Damages were determined for floods having a 5-percent, 1-percent, and 0.5-percent exceedence frequency.

25. TYPES OF FLOOD DAMAGES

All flood damages in Chaska are classified as urban and include residential, commercial, and public damages. Residential losses include physical damages to dwellings and their contents, other personal property, and the cost of temporary quarters during flood emergencies. Losses to commercial establishments include physical damages to buildings, equipment, and stocks of merchandise; and losses due to interruption of business, including wages not earned by employees and profits not earned by the firm. Losses to public properties include physical damages to streets, sidewalks, parks, schools and other public buildings, a city well, sewers, and sewage treatment facilities. Other public losses include additional costs incurred by local and State governments during floods for emergency relief activities and overtime work by the police, firemen, and other public employees.

26. Estimates of flood damages likely to be caused to commercial and public properties by inundation to various depths were obtained in interviews with businessmen and public officials. Residential damages were estimated by determining the approximate market value of each floodplain residence, the elevation of the ground, and the elevation of the first floor. Damages were then computed by using the standard depth-damage tables of the St. Paul District.

27. ESTIMATED FLOOD DAMAGES - PRESENT CONDITIONS

Tables C-10 and C-11 show the flood damages in February 1973 prices on East Creek and Chaska Creek and the ponding area behind the Minnesota River levee for 5-percent, 1-percent, and 0.5-percent hypothetical floods. Approximately 78 percent of the potential 1-percent flood damages would be residential, about 13 percent commercial, and 9 percent public. Under present conditions, floods cause damages in the various damage reaches when flood flows exceed the elevation or discharges listed in table C-12.

Table C-10 - Estimated flood damages, East and Chaska Creeks, Chaska, Minn.

Damage category	5-percent chance flood	1-percent chance flood	0.5-percent chance flood
Residential	$2,159,000	$3,586,000	$3,637,000
Commercial	69,000	591,000	798,000
Public	3,000	379,000	463,000
Total	2,231,000	4,556,000	4,898,000

Table C-11 - Estimated flood damages behind Minnesota River levee, Chaska, Minn.

Damage category	5-percent chance flood elevation 718	1-percent chance flood elevation 723	0.5-percent chance flood elevation 725
Residential	$1,198,700	$2,212,100	$3,075,100
Commercial	24,000	190,000	239,000
Public	3,000	369,000	448,000
Total	1,225,700	2,771,100	3,762,100

Table C-12 - Elevation and discharge at which flood damage begins

Reach	Elevation (feet)	Discharge (cfs)
East Chaska Creek		500
West Chaska Creek		1,000
Ponding area behind Minnesota River levee	713.0	

28. The estimated flood damages at Chaska were the basis for developing stage-damage and discharge-damage curves. Average annual damages, which are estimated to amount to $498,000 at February 1973 price levels, were derived by correlating discharge-damage and discharge-frequency relationships, as shown on plates C-3 and C-4.

29. ESTIMATED FUTURE GROWTH OF FLOOD DAMAGES

The economic base study and available land-use information provide the basis for estimating future flood damages. Future growth of damages at Chaska was estimated by projecting: (1) new development damages related to land-use changes, and (2) damages associated with improvement of existing structures and their contents. The approximate proportions of annual equivalent increase in damages attributed to new construction and improvement to existing development are 7 and 93 percent, respectively.

30. NEW DEVELOPMENT GROWTH

The extent to which new construction development is expected to locate in the Chaska floodplains represents one component of future damage growth. A comparison of existing land use (plate C-1) and future land use (plate C-2) under ultimate development conditions was used to determine the acres which are presently vacant and which are expected to be developed in the future. The replacement of existing damageable units and subsequent redevelopment acres available in the future have also been estimated as a source of new development growth. The Minnesota River area will have only redevelopable acreages subject to new construction growth. The East and Chaska Creek area has approximately 54 currently vacant floodplain acres which will be developed. Since existing development in the creeks area is comparatively new, future growth from replacement will not be a factor until some time after 1990. The new development pattern is further discussed in conjunction with flood proofing cost savings and land utilization benefits (see paragraphs 38-40).

31. A determination of per acre density of average annual damages ($2,050) under existing conditions was made and then modified for differing conditions expected in the future. Differing conditions under which new development will take place are as follows:

a. Sound floodplain management regulation will eliminate nearly all damages except for incremental damage growth above the 100-year protection level.

b. New construction will have higher structural value and therefore higher densities of average annual damage.

c. New development will occur at a variety of higher levels of per capita income and spending.

The small incremental growth in damages due to new development growth shown in table C-13 is net of the above changes tending to increase or decrease future new growth damages. These damages will be incurred despite strict enforcement of floodplain development and are primarily residual damages above, and limited allowable damage growth below, the degree of required flood proofing.

Table C-13 - Detailed estimate of present and future average annual flood control damages, Chaska, Minn.

Type of damage and area affected at Chaska	Average annual flood control damages: 1973-1974	Index of change 1974-1980	1980	Index of change 1980-2030	2030	100-year project life: Actual increase	Average annual equivalent increase at 5 5/8 percent	Total average annual equivalent damage over 100-year life of project at 5 5/8 percent
I. Minnesota River area								
A. New development damage growth alone - all categories	$129,600	1.011	$131,000	1.125	$147,400	$16,400	$5,700	$136,700
(net increase)	(0)		(1,400)		(16,400)			(5,700)
B. Damage growth due to existing development alone								
1. Residential	111,400	1.058	117,900	1.930	227,500	109,600	38,200	156,100
2. Commercial	11,700	1.147	13,400	2.952	39,600	26,200	9,100	22,500
3. Public	6,500	1.067	6,900	2.034	14,000	7,100	2,500	9,400
Subtotal	129,600	1.066	138,200	2.034	281,100	142,900	49,800	188,000
(net increase)	(0)		(8,600)		(142,900)			(49,800)
C. Total Minnesota River area With cumulative future growth	129,600	1.082	139,600	2.141	298,900	159,300	55,500	195,100
	(0)		(10,000)		(159,300)			(55,500)
II. East and Chaska Creek area								
A. New development damage growth alone - all categories	369,200	1.010	372,900	1.087	405,300	32,400	11,300	384,200
(net increase)	(0)		(3,700)		(32,400)			(11,300)
B. Damage growth due to existing development alone								
1. Residential	307,900	1.083	333,500	2.268	756,400	422,900	147,400	480,900
2. Commercial	39,500	1.180	46,600	3.180	148,200	101,600	35,400	82,000
3. Public	21,800	1.094	23,800	2.380	56,600	32,800	11,400	35,200
Subtotal	369,200	1.094	403,900	2.380	961,200	557,300	194,200	598,100
(net increase)	(0)		(34,700)		(557,300)			(194,200)
C. Total East and Chaska Creek areas	369,200	1.104	407,600	2.447	997,300	589,700	205,500	613,100
With cumulative future growth	(0)		(38,400)		(589,700)			(205,500)

32. GROWTH TO EXISTING DEVELOPMENT

Future growth in damages also stems from existing development which will continue to be situated on the floodplains at Chaska, with or without the project. Increases in damages will result from physical changes including a variety of property improvements, numerous types of damage extension, and higher intensity of existing facility usage, generally unaffected by floodplain regulations. An assumption used for determining growth to existing development at Chaska was that a limited examination of existing category damages would reveal which damages are susceptible to change due to income, population, or production changes. Subject to particular limitations, the expected increase in flood damages to residential and commercial property anticipated from physical property changes was estimated to equal the change in per capita income for OBE area 06094.

33. The growth to existing development index for residential damage, shown in table C-13, is the per capita income index reduced by 54 percent due to identification of existing residential damages not considered to increase with per capita income. A further reduction was made for each damage area by the unique rate of replacement of aged residential structures. Most of the residential damage increase constitutes greater damage to improved contents with the remaining increase due to structural improvements to existing property.

34. The growth to existing development index for commercial damage is per capita income reduced at a constant rate over the life of the project to reflect business failures and building replacements. Damages to light commercial units and changes in retail sales per establishment would be expected to closely follow the upward trend in per capita income for Chaska. Commercial establishments in general have regenerative capacities to survive, to initiate improvements, and to grow that might not as quickly be reflected in residential units subject to the same per capita income increases.

35. Finally, existing public damages can also be expected to increase as upgrading of public facilities and service systems takes place. Public improvements, over a long growth period, can be expected to reflect increased demands by residents, businesses, and industry for improved public services. In the Chaska floodplain, the public category of growth to existing development will be increased proportionately to the total increase in growth to existing development in the private sector of the economy. The monetary values for the growth to existing development plus new development growth in Chaska are shown in table C-13.

EVALUATION OF PROJECT BENEFITS

36. FLOOD CONTROL BENEFITS

Primary flood damage reduction benefits are the difference in average annual flood damages with and without the recommended project. Plates C-3 and C-4 show existing conditions average annual damages and related benefits. Present and future flood control benefits summarized in table C-14 have been projected using the same rates as those previously used to determine growth in average annual damages, table C-13. Average annual equivalent flood damage reduction benefits attributable to the proposed levee on the Minnesota River at Chaska are estimated to be $133,100 (see table C-14). Similar damage reduction benefits attributable to diversion of East and Chaska Creeks are estimated to be $580,200. Total flood control benefits including future growth are estimated to be $713,300. None of these are induced benefits because the damage reduction would otherwise be incurred in the absence of the project. Average annual equivalent residual flood damages over the life of the project are estimated at $94,900. Additional tangible benefits would accrue due to relief of infiltration into the sewer system under flood conditions. However, these benefits have not been determined at this time.

Table C-14 - Summary of estimated present and future flood damages and benefits, Minnesota River area and East and Chaska Creeks

Conditions	Average annual damages and benefits 1973	Average annual damages and benefits 1980	Average annual damages and benefits 2080	Increase in damages and benefits (1980-2080)	Average annual equivalent of increase over 100-year project life (1980-2080)(1)	Total average annual equivalent damages and benefits over 100-year project life
Minnesota River area						
Without project	$129,000	$139,600	$298,900	$159,300	$55,500	$195,100
With project	41,000	44,400	95,000	50,600	17,600	62,000
Benefits	88,000	95,200	203,900	108,700	37,900	133,100
East and Chaska Creeks						
Without project	369,200	407,600	997,300	589,700	205,500	613,100
With project	19,800	21,900	53,500	31,600	11,000	32,900
Benefits	349,400	385,700	943,800	558,100	194,500	580,200
Total for combined areas						
Without project	498,200	547,200	1,296,200	749,000	261,000	808,200
With project	60,800	66,300	148,500	82,200	28,600	94,900
Benefits	437,400	480,900	1,147,700	666,800	232,400	713,300

(1) Straight-line growth for 50 years and no growth for the last 50 years of 100-year project life at 5 5/8 percent interest = 0.3485.

37. The above benefit analysis was calculated under the assumption that flooding from the Minnesota River and flooding from Chaska Creek and East Creek would occur as independent flood events. However, since these flood events can reasonably be expected to coincide about 1 percent of the time, a redundant benefit of about $2,000 occurs in the analysis resulting from a duplication in benefits calculated for the floodplain area behind the existing levee system. In addition, a small residual 100-year floodplain remains on East Creek from uncontrolled drainage below the proposed diversion (see plate 3). The residual average annual equivalent damage has been calculated to be $2,400. Accordingly, together with the $2,000 redundant benefit, $2,400 average annual equivalent residual damages reduces total overall average annual equivalent flood control benefits to $708,900.

38. FLOOD PROOFING COST SAVING BENEFITS - VACANT LAND

The floodplain at Chaska consists of approximately 390 acres, including the areas behind the Minnesota River levee and along East and Chaska Creeks as listed in table C-8. Vacant land, mainly along East Creek, accounts for 37 percent of the total land area in the floodplain. The vacant area along East Creek is low and may be filled in accordance with floodplain regulations for commercial or residential uses. Maps showing existing land use and future land use at Chaska are provided on plates C-1 and C-2, respectively. Land use shown on these maps was taken from existing zoning and land use and from the planning studies of the Jonathan Development guide plan and was confirmed as the expected developmental pattern in consultations with city officials.

39. Of the 147 acres of vacant land located mainly along East Creek, approximately 54 acres within the 100-year flood outline (as seen by comparing colored plates C-1 and C-2 and plate 2 in the main report) would be developed for higher use during the life of the project. Approximately 21.7 acres, colored purple; 4.4 acres, colored red; and 27.9 acres, colored yellow would be used for industrial, commercial, and residential purposes, respectively. These vacant acres would be developed with or without the project. A saving in flood proofing costs which would otherwise be associated with floodplain development represents a tangible benefit of the proposed flood control project. Flood proofing would consist of raising the ground elevation up to the 100-year plus 1 foot flood elevation. A cost saving in fill would amount to an annual benefit of $39,600 as derived in table C-15.

Table C-15 - Computation of flood proofing cost saving benefit for vacant lands

Item	Amount		
<u>Industrial reach - 21.6 acres</u>			
Acre-feet of fill required	1.98 feet X 21.6 acres = 42.77 acre-feet		
Total cost of fill	42.77 acre-feet X $3,226 per acre-foot =		$138,000
Cost saving benefits at present worth	$138,000 X 0.7859(1)	=	108,400
Annualized benefits using 8-percent rate of return(2)	108,400 X 0.08	=	8,700
<u>Commercial reach - 4.4 acres</u>			
Acre-feet of fill required	3.8 feet X 4.4 acres = 16.7 acre-feet		
Total cost of fill	16.7 acre-feet X $3,226 per acre-foot =		53,900
Cost saving benefits at present worth	$53,900 X 0.7859(1)	=	42,400
Annualized benefits using 8-percent rate of return(2)	42,400 X 0.08	=	3,400
<u>Residential reach - 27.7 acres</u>			
Acre-feet of fill required	4.9 feet X 27.7 acres = 135.7 acre-feet		
Total cost of fill	135.7 acre-feet X $3,226 per acre-foot =		437,770
Cost saving benefits at present worth	$437,770 X 0.7859(1)	=	344,000
Annualized benefits using 8-percent rate of return(2)	344,000 X 0.08	=	27,500
<u>Summary of categories of use and benefits</u>			
Industrial			8,700
Commercial			3,400
Residential			27,500
Total average annual benefits			39,600

(1) Assume 20-year accelerated growth at 5 5/8 percent discount.
(2) Private sector rate of return on investment.

40. FLOOD PROOFING COST SAVING BENEFITS - RENEWAL AND REDEVELOPMENT LAND

In addition to development of vacant land, another source of new development growth is to houses which are old, substandard, and depreciated to the point where they would be torn down and replaced during the life of the project. A survey of houses in the floodplain indicated that approximately 113 houses in the floodplain might be replaced during the life of the project. Minimal house replacement would occur in the new development northeast of old Chaska on East Creek since the houses in this area are comparatively new. Of the 113 houses, approximately 42 houses are located on the fringe area of the flood outline where flooding would be less frequent and to a lesser depth. Without the project, replacement houses could be constructed and flood proofed but at additional cost since these renewal acres must also be in compliance with floodplain regulations. With the project in place, $4,600 annual cost saving benefits would be realized because the replacement structures would not have to be flood proofed. Table C-16 shows the derivation of redevelopment annual cost saving benefits.

Table C-16 - Computation of redevelopment annual cost saving benefits

Item		Amount
Number of houses on floodplain fringe		42
Average number of houses per acre of floodplain		5
Acres to be flood proofed - 42 houses ÷ 5 houses per acre	=	8.4 acres
Fill required to flood proof 1 acre		2.7 feet
Fill required to flood proof 8.4 acres - 2.7 feet X 8.4 acres	=	22.68 acre-feet
Cost of fill per acre-foot		$3,226
Total cost of fill required - 22.68 acre-feet of fill X $3,226	=	73,900
Cost saving benefits at present worth - $73,900 X 0.7859(1)	=	58,000
Annualized benefits using 8-percent rate of return(2) - $58,000 X 0.08	=	4,600

(1) Assume 20-year accelerated growth at 5 5/8 percent discount.
(2) Private sector rate of return on investment.

41. IMPROVED LAND UTILIZATION BENEFITS

Of the 113 houses likely to be replaced, 71 houses are low and subject to frequent and deep flooding. These houses could not be replaced with new structures in accordance with floodplain regulations due to prohibitive costs of fill and other required flood proofing measures. The "without project" alternative is to maintain depreciated and deteriorated structures which are (or will be) in need of replacement. This is particularly true since the alternative (and longer term eventuality) to maintaining the existing structures would be to put these lots into disuse. The "with project" condition would eliminate frequent flood damages, allowing timely redevelopment. An improved land utilization benefit would accrue due to the difference in land use without the project compared with project conditions use. These benefits are estimated at $14,300 annually and are presented in table C-17.

Table C-17 - Computation of average annual improved utilization benefits

Item	Value by lots	Total value
1. Approximate number of better utilized lots	71	71
2. Value of lots under flood risk conditions	$600	$42,600
3. Future utilized value	4,200	298,200
4. Gross utilization increase per lot	3,600	255,600
5. Development costs(1)	400	28,400
6. Net utilization per lot	3,200	227,200
7. Present worth factor to discount utilization at 5 5/8 percent(2)	0.7859	0.7859
8. Utilization benefits at present worth	$2,360	$178,600
9. Annualized utilization benefits using 8-percent rate of return	190	14,300

(1) Development costs would be minimal since the sewer and water are already in, and the project would eliminate the necessity of fill or flood proofing.
(2) Assume 20-year accelerated growth at 5 5/8 percent discount.

42. SUMMARY OF FLOOD CONTROL AND RELATED BENEFITS

Benefits attributable to a plan which provides intermediate regional flood protection include tangible flood control benefits from reduction of flood damages, flood proofing cost saving benefits for vacant land and renewal and development lands, and improved land utilization benefits. Table C-18 tabulates these benefits.

Table C-18 - Summary of average annual flood control and related benefits, Chaska, Minn.

Flood control benefits	
Minnesota River area	$133,100
East and Chaska Creeks area	580,200
Residual flood damage from uncontrolled drainage area	-2,400
Coincidental flood damages	-2,000
Total flood control benefits	708,900
Related benefits	
Flood proofing cost savings - new development	39,600
Flood proofing cost savings - redevelopment	4,600
Improved land utilization benefits	14,300
Total related benefits	58,500
Total flood control and related benefits	767,400

PLAN FORMULATION

43. OBJECTIVES

The basic objectives of plan formulation are to develop a plan which will provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs of the Chaska area. In pursuit of this general objective, the following specific planning principles and objectives guided formulation of the plan of improvement.

a. The plan must preserve to the maximum possible extent the quality of the natural and human environment.

b. The plan must be socially acceptable.

c. The plan must enhance the economic welfare of the local people and add to their security and well-being.

d. The plan must enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.

e. The plan must fit integrally into an overall plan for water and related land resource management and development for the Upper Mississippi River basin.

f. The plan must be technically feasible to implement.

44. CONSIDERATION OF THE WATERSHED NEEDS

There is an existing or pending need for water quality control, recreation, fish and wildlife enhancement, and flood control in or downstream from the East and Chaska Creek watersheds. Glacial till and other deeper aquifers provide a good source of groundwater which should meet the foreseeable water supply needs of the Chaska area. The only water quality problem anticipated in the area is on the Minnesota River downstream from the existing wastewater treatment plant where oxygen depletion could occur during times of low streamflow. Advanced waste treatment, low-flow augmentation, or on-land disposal of wastewater are methods which might prove effective in coping with the problem. The Metropolitan Development Guide Plan indicates the existing treatment plant at Chaska will be phased out between 1985 and 2000. Raw sewage will then be pumped to a regional treatment plant east of Shakopee. This may help to reduce the potential water quality problems. These and related problems of the Chaska area will be considered further in the Minnesota River basin survey study.

45. ALTERNATIVE METHODS OF MANAGING THE FLOODPLAIN

A comprehensive and effective plan for managing the floodplains of a particular river basin or locality may include any combination or all of the known measures for flood damage reduction or prevention. Such a program would logically include one or a mix of the following nonstructural and structural measures:

a. Nonstructural measures. -

(1) Flood proofing of existing or new structures.

(2) Flood warning systems.

(3) Permanent evacuation.

(4) Flood insurance.

(5) Floodplain regulation.

b. Structural measures. -

(1) Reservoir storage.

(2) Levees and floodwalls.

(3) Channel improvements or diversions.

All of these measures were fully investigated for the East and Chaska Creek watersheds, and Chaska in particular. All alternative plans were compared using a 5 5/8-percent discount rate and an assumed 100-year project life.

46. NONSTRUCTURAL ALTERNATIVES

The nonstructural flood damage reduction measures studied include a flood forecasting and flood warning system, floodplain evacuation, flood proofing existing structures, flood insurance, and floodplain regulation. A brief description of each plan follows:

a. Plan 1. - A flood forecasting and flood warning system presently available for the Minnesota River through thr National Weather Service and the St. Paul District, Corps of Engineers, provides Chaska city officials and local news media with reliable flood forecasts and warnings. However, little or no warning could be given if intense rainfall caused a flash flood on East and Chaska Creeks. With this alternative the social situation would remain depressed due to the anxiety and worry experienced by local residents during flood seasons and due to the community disruption which occurs during actual floods. Also, the questionable structural integrity of the existing emergency levee system and flash flood potential of East and Chaska Creeks impose an unacceptable high risk of catastrophic damage and potential for loss of life in the community. Accordingly, flood forecasting and flood warnings with subsequent emergency actions are considered to be unacceptable long-term solutions to the Chaska flood problem.

b. Plan 2. - Floodplain evacuation, although completely unacceptable to local interests, has been analyzed. About 540 residences, 47 businesses and industries, and three public buildings are currently within the floodplain. The massive social, institutional, and physical problems make the practicality of this measure very questionable. Community cohesion would be severely disrupted and long-standing sociological and historical ties would be lost. Further, it is questionable whether the remaining urbanized area could continue to function as a viable economic and social unit. Estimated costs associated with floodplain evacuation exceed $21 million. The benefit-cost ratio is 0.6 This impact is based upon the assumption that all relocations would be made to biological systems which are less sensitive than those of the bottomlands, which would result in a net environmental gain to the natural system. In this regard, floodplain evacuation would be the most preferable of the alternatives in terms of the environmental quality planning objective. However, if the relocations would require alterations of more sensitive biological systems, a net loss to environmental quality could result, requiring a corresponding reduction in its ranking from the standpoint of environmental quality.

c. Plan 3. - Flood proofing of all existing buildings is not practicable since most structures are not designed to withstand the high heads involved. Raising the flood-prone structures several feet, when physically possible, and removing structures which are not feasible to raise would entail costs exceeding $19 million. This plan is not economically feasible in Chaska. In addition, the "perched" appearance

of the raised buildings and the massive loss of trees inherent in the flood-proofing process would be environmentally detracting and aesthetically unappealing. Sociological effects of flooding, such as disruption of transportation, isolation of residents from their homes and businesses, curtailment of commerce, and potential dangers to public health and safety would remain.

d. Plan 4. - Flood insurance is currently available in Chaska for areas subject to flooding from the Minnesota River. A total of 72 properties were protected by the insurance as of April 1973. Thus, flood insurance has not received broad-based public acceptance since less than 15 percent of the flood-prone structures have been insured. Flood insurance does not solve the flood problem since it only spreads the monetary loss over a wider population sector and does not reduce the actual damage. The impacts of this alternative would actually be controlled by the existing floodplain regulation which is discussed below as plan 5.

e. Plan 5. - The city of Chaska in cooperation with the State of Minnesota has implemented a floodplain regulation program along the Minnesota River within the city. The East and Chaska Creek floodplains, which have been delineated as part of the present study, will be regulated in the near future. Rather than precluding floodplain development, sound floodplain regulation shapes floodplain land use and development so as to lessen the damaging effects of floods. Chaska's floodplain regulation program involves the use of legal tools to control the extent and type of future development which will be permitted in the floodplains. Although floodplain regulation exhibits a favorable benefit-cost ratio of 2.6, the average annual equivalent damages exceeding $800,000 would remain within Chaska because of the dense existing urban developments and the likelihood that urban land use would not appreciably change in the foreseeable future. This leads to the conclusion that floodplain regulation alone could not be expected to minimize total flood hazards representing the costs of any corrective measures plus damages remaining.

47. STRUCTURAL ALTERNATIVES

a. Plan 6. - Plan 6 includes the diversion of Chaska Creek around the heavily developed areas of Chaska and the provision of a flood bypass for East Creek as described for the proposed plan. The proposed modifications would require earthen embankments to divert the flood flows into rock-lined channels which would carry floods safely to the Minnesota River floodplain. Approximately 28 acres of undeveloped commercial and industrial land would be taken out of production with attendant loss of tax base. In addition, three houses and six mobile homes would require relocation. However, over 100 acres of intense urban development including 284 homes, 18 businesses, two public buildings, the city waste water treatment plant and system, Courthouse Lake, streets, roads, and public utilities would remain subject to flooding from the Minnesota River. Although the benefit-cost ratio of this plan is 1.9 and would reduce flood damage by about 72 percent, this alternative alone would not provide a

complete and adequate solution to Chaska's flood problem. The environmental impacts of this alternative are described as part of the discussion of plan 8. Maintenance of normal low flows in the existing East Creek channel and possible development of environmental interpretive trails along forested and marshy areas of the creek would enhance human appreciation of the environment.

b. Plan 7. - The upgrading and extension of the existing emergency levee combined with the provision of adequate interior drainage facilities would give intermediate regional flood protection from the Minnesota River. Although the urbanized area behind the levee system would be adequately protected from floods on the Minnesota River, it would have no protection against flash floods on East and Chaska Creeks which could overflow and fill the leveed area from the landward side. In addition, this plan provides no flood protection for urban development along the Chaska and East Creek floodplains. Accordingly, the entire community would remain subject to flood damages from the two creeks. This fact is emphasized by the fact that flood damages would be reduced by only 16 percent with this plan. Thus, this alternative alone would not provide a complete and adequate flood damage reduction solution to Chaska's flood problem. The environmental impacts of this alternative are described as part of the discussion of plan 8.

c. Plan 8. - This alternative includes the combination of plan 6 and plan 7 to provide intermediate regional flood protection from all flood sources. About 540 homes and 47 businesses in low-lying areas would be protected in addition to the three public facilities that lie in the floodplain. The benefit-cost ratio would be 1.3 with total flood damages reduced bv 88 percent. About 2 acres of trees along the existing levee and 3 acres in the area of the levee extension would be lost. However, aesthetic treatment and tree plantings included in the plan would partially offset these losses. In the area of proposed diversions, 9 acres would have to be cleared of interspersed trees and brush. Although this plan would require the relocation of 13 residences, public opinion in favor of the plan is strong. This coupled with the increased security and well-being to the people afforded by the plan fulfills the social well-being objective in planning. Also by providing overall protection, home and business loans guaranteed by various Federal agencies could be obtained in Chaska since the area would not be designated as a floodplain by the State of Minnesota and Executive Order 11296.

d. Plan 9. - The construction of four headwaters reservoirs in the East and Chaska Creek watersheds could reduce intermediate regional flood peak flows by approximately 40 percent in Chaska. The benefit-cost ratio would be 0.9 and average annual flood damages in Chaska would be reduced by only about 29 percent. Some 600 acres of land including 100 acres of cropland and 400 acres of marshland would be used. The use of dry dams as proposed would conflict with Jonathan Development Corporation plans to construct small, fixed-pool recreation reservoirs primarily for aesthetic purposes in this area.

Periodic inundation of the marsh areas would lead to some loss of wildlife habitat, but this would be offset by the additional area of wet marshland and accompanying habitat that would be created by the sediment reserve pools of these dams. Socially this alternative would not be acceptable because flood damage from the Minnesota River and the creeks would remain severe.

e. Plan 10. - The four headwaters reservoirs described under plan 9 could be combined with channel diversions for East and Chaska Creeks plus upgrading the existing levee and interior drainage facilities to provide protection from the intermediate regional flood. The benefit-cost ratio would be 1.0 with all benefits associated with flood control evaluated. Socioeconomic and ecological impacts would be similar to those of plans 6, 7, and 9.

f. Plan 11. - Two large earth-fill dams, one on East Creek and the other on West Creek, immediately upstream from where each creek exits into the Minnesota River valley would provide intermediate regional flood protection from the streams. However, the benefit-cost ratio would be only 0.7. Such reservoirs would require the relocation of major trunk sewer lines, a heavily used county road, and several residences. Approximately 70 acres of heavily wooded stream valley would be lost and a planned creek greenway system would be severed.

g. Plan 12 - The two large reservoirs described in plan 11 could be combined with the levee improvements of plan 7 to provide intermediate regional flood protection for the community. The benefit-cost ratio would be 0.7. Socioeconomic and ecological impacts would be identical to those described for plan 7 and plan 11 but the city would have a complete plan of protection.

h. Plan 13 - Approximately 2.5 miles of channel improvement through Chaska on East and Chaska Creeks constitute this plan. The proposed works would consist of enlarging, deepening, and refinishing the existing channel linings using grass riprap or concrete surfacing or combinations of these materials. The benefit-cost ratio would be 1.5. Substantial ecological changes along East Creek could be expected where about 25 acres of forest would be removed and marshy areas adjacent to the stream would be drained. The large channel required would be generally displeasing aesthetically and difficult to maintain. Approximately 26 residences and three businesses would require relocation and every bridge in Chaska would have to be replaced.

i. Plan 14. - The channel improvement on East and Chaska Creeks as described in plan 13 could be combined with the levee improvement of plan 7 to provide intermediate regional flood protection for Chaska. The benefit-cost ratio would be 1.2 with all benefits associated with flood control evaluated. Socioeconomic and ecological impacts would be identical to those described in plans 7 and 13.

48. MAINTAIN THE STATUS QUO

Consideration was given to maintaining the status quo or recommending that no action be taken to alleviate flood problems. To do nothing would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at over $1 million would remain and, as such, would be a severe social and economic burden to the people. Natural riverine aesthetics would probably not change significantly in designated park areas. However, as normal economic growth occurred, infringement on the river corridor in other areas by businesses, industries, and residences would likely result in degradation of the natural riverscape. Furthermore, provisions for flood protection from major floods on the Minnesota River would be dependent on the construction of emergency levees and temporary interior drainage facilities. In view of the flash flooding that can occur at Chaska from East and Chaska Creeks, reliance on emergency measures for the entire city would be hazardous during Minnesota River floods and ineffective for flash floods on the two creeks.

49. DISCUSSION OF ALTERNATIVES

All alternatives were analyzed using the following three parameters:

a. Environmental quality. - The plan must have no irreconcilable adverse environmental impact.

b. Social well-being. - The alternative must provide a major reduction in flood damages from all sources. Only plans which offer intermediate regional flood protection from these sources are supported by the public and are considered socially acceptable. Relocation of residences and businesses should be minimal.

c. Economic and technical feasibility. - The alternative must be physically possible to implement. The sum total of tangible and intangible benefits must exceed the combined tangible and intangible costs.

d. The plan must be supported by the public.

Table C-19 summarizes the effects that each plan would have on the above parameters. Failure to adequately satisfy the minimum standards prescribed for each criterion was grounds for exclusion of that alternative.

TABLE C-19 - ALTERNATIVE METHODS OF MANAGING THE FLOODPLAIN AREAS OF CHASKA, MINNESOTA (1)(2)(3)

Item	No action	Plan 1 Flood fore-cast warning	Plan 2 Flood plain evacu-ation	Plan 3 Flood proof-ing	Plan 4 Flood insur-ance	Plan 5 Flood plain regu-lation	Plan 6 Creek diver-sion	Plan 7 Upgrade levees	Plan 8* Divert creeks and upgrade levees	Plan 9 Four head-waters reser-voirs	Plan 10* Four reservoirs and diversions and levees	Plan 11 One reser-voir each creek	Plan 12* One reservoir each creek and levees	Plan 13 Channel improve-ment	Plan 14* Channel improve-ments and levees
Total first cost ($ million)	0	?	21.65	19.37	?	0.05	5.39	4.15	9.54	4.05	12.89	13.81	17.96	6.57	10.72
Average annual cost ($1,000)	0	?	1,223	10.94	283	40	307	249	556	249	765	800	1,049	375	624
Average annual benefits ($1,000)	0	?	728	664	?	102	578	131	709	234	709	563	709	563	709
Net average annual benefits	0	?	-495	-428	?	62	271	-118	153	-15	-56	-237	-340	188	85
Average annual damages remaining ($1,000)	908	806	78	140	806	806	228	675	.97	572	97	243	97	243	97
Benefit-cost ratio	-	?	0.6	0.6	?	2.6	1.9	0.5	1.3	0.9	0.9	0.7	0.7	1.5	1.1
Federal average annual cost ($1,000)	0	?	938	875	?	?	239	228	453	186	624	692	920	302	445
Non-Federal total average annual cost ($1,00	0	?	245	219	?	?	68	21	103	63	141	108	129	73	179
Non-Federal annual operation and maintenance cost ($1,000)	0	?	?	?	?	?	3	14	17	20	37	20	34	4	18
Residences relocated or purchased	0	0	344	296	0	0	9	4	13	0	13	4	8	26	30
Businesses relocated or purchased	0	0	47	47	0	0	1	0	1	0	1	0	0	3	3
Lands removed from floodplain (acres)	0	0	0	0	0	0	340	80	420	50	425	345	425	375	455
Parkland lost (-) or gained (+)* (in acres)	0	0	+100	+80	0	0	0	0	0	0	0	0	0	-16	-16
Floodplain zoning utilized	No	Major	Major	Major	Major	Major	Major	Major	Some	Major	Some	Major	Some	Major	Some
Cropland lost or gained (acres)	0	0	0	0	0	0	0	0	0	-100	-100	-5	-5	0	0
Pastureland lost or gained (acres)	0	0	0	0	0	0	0	0	0	-95	-95	-20	-20	0	0
Increased safety of buildings	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Increased safety of people	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Population loss from area	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
Community cohesion lost	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
Loss of tax base	None	None	Major	Some	None	Some	Minor	Minor	Some	Some	Minor	Minor	Minor	Minor	Minor
Adverse effect on local school district	None	None	Major	Some	None	None	None	None	None	Some	Some	Some	Some	None	None
Socially important sites affected	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	No	No
Miles of roadway affected	0	0	24.0	10.0	0	0	0	0	.2	.5	0.7	2.5	2.5	0	0
Utility networks affected															
Sewer lines (miles)	0	0	10.0	4.0	0	0	0.1	0.7	0.8	0	0.8	4.0	4.7	0	1.0
Communication lines (miles)	0	0	12.0	5.0	0	0	0	0.1	0.1	0.5	0.6	1.0	1.1	0	0.1
Waterlines (miles)	0	0	10.0	4.0	0	0	0	0.1	0.1	0.0	0.1	2.0	2.1	0	0.1
Powerlines (miles)	0	0	12.0	5.0	0	0	0.2	0.9	0.4	0.5	0.9	1.0	1.2	0	0.2
Improved public health	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Improved water supply	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Trees lost from urban setting (acres)	0	0	10	30	0	0	3	.2	5	0	5	70	78	85	87
Loss of streambank cover in city (acres)	0	0	0	0	0	0	0	0	?	0	0	70	70	85	85
Regimentation of riverscape	No	No	No	No	No	No	Yes	No	Yes	No	No	No	No	Yes	Yes
Architectural treatment of structures	No	No.	No	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Hunting (better)	No	No	Yes	No	No	No	No	No	No	Yes	Yes	No	No	No	No
Fishing (better)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Trapping (better)	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No
Increased stream erosion and sedimentation	Same	Same	Same	Same	Same	Same	Same	Same	Less	Less	Less	Less	Less	More	More
Sedimentation of channels or drains requiring maintenance	Same	Same	Same	Same	Same	Same	More	Same	More	Less	More	Less	Less	More	More
Land forms rendered less scenic	No	No	?	?	No	No	Yes	Yes	Yes	?	?	?	?	Yes	Yes
Water surface area change (+) or (-)(acres)	0	0	0	0	0	0	0	0	0	+195(6)	+195(6)	+40	+40	0	0
Linear miles of natural stream lost or gained	0	0	0	0	0	0	0	0	0	0	0	0	0	-2.75	-2.75
Eutrophication of reservoirs	No	No	No	No	No	No	No	No	No	Likely	Likely	Likely	Likely	No	No
Stream water quality improved	Same	Same	Same	Same	Same	Same	Same	Same	Same	Yes	Yes	Yes	Yes	Same	Same
Temperature rise in streams	No	No	No	No	No	No	Yes	No	Yes	No	Yes	No	No	Yes	Yes
Water table locally raised (rural)	No	No	No	No	No	No	No	No	No	Slight	Slight	Slight	Slight	No	No
Water table lowered (developed area)	No	No	No	No	No	No	Yes	No	Yes	No	Yes	No	No	Yes	Yes
Low flow augmentation	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Wetlands lost (-) gained (+)(acres)	0	0	0	0	0	0	-4(7)	-3	-7(7)	[illegible](8)	[illegible](8)	95(8)	95(8)	-15	-90
Low woodland lost (acres)	0	0	0	0	0	0	-8	-3	-7	?(8)	?(8)	?	?	85	30
Upland woodland lost (acres)	0	0	0	0	0	0	-3	0	Same	-10	-13	-70(8)	-70(8)	0	0
Riparian corridors created	No	No	No	No	No	No	Yes	No	Yes	No	Yes	No	No	No	No
Natural settings changed	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wilderness areas affected	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

* Plans which provide intermediate regional flood protection (1-percent chance flood).
(1) Floodplain regulation was assumed to be in effect for all alternatives except "no action".
(2) Interest during construction is not considered in any of the alternatives.
(3) Average annual benefits include only flood control benefits.
(4) A question mark indicates that the effect could not be determined with present data.
(5) This table is based on a 5 3/8-percent discount rate and a 100-year project life.
(6) Represents a change from dry to wet marsh.
(7) An additional 30 acres of partially drained wetland would be completely drained by these alternatives.
(8) Periodically inundated.

50. Plans 1, 2, 3, 4, and 5 (table C-19) which utilized nonstructural alternatives were all relatively high in environmental quality but failed to adequately satisfy the social well-being or public acceptability parameter, to show economic feasibility, or both. Flood forecasting and warning, plan 1, is available for the Minnesota River. Hydrologic studies of Chaska and East Creek watersheds, however, have revealed that little or no warning could be given if intense rainfall caused flash flooding on East and Chaska Creeks and, hence, the damages from flash flooding would remain severe. Plans 2 and 3, which advocate evacuation of the floodplain or flood proofing existing and future development, would be unacceptable both socially and economically. The cost to move flood-prone structures or flood proof them far exceeds the possible flood damages prevented. In addition, public opposition to any plan which would relocate the hundreds of residences is certain. Flood insurance, plan 4, has been available since March 1971 in Chaska. However, less than 15 percent of the flood-prone structures in Chaska have been brought under the protection of this program. Thus, flood insurance has not received broad-based public acceptance at Chaska and, since flood damages would not be alleviated in any way, this alternative is not considered to be an adequate solution to the problem. In contrast to the above alternatives, plan 5 which utilizes floodplain regulation would provide significant benefits for a relatively small cost. Thus, by precluding unwise future development, potential flood damages could be frozen at present levels. However, no relief from the estimated $806,000 average annual equivalent flood damages would be provided. Consequently, floodplain regulation, although highly desirable, could not be expected to significantly minimize flood damages in Chaska and is considered a supplement to, rather than a substitute for, other measures which could substantially reduce flood damages.

51. Of the structural alternatives available, plans 6, 9, 11, and 13 offer only protection from flooding on Chaska and East Creeks. Plan 7 would protect the developed area of Chaska only from Minnesota River flooding. In coordination meetings and public meetings, Chaska citizens have repeatedly stated that they will support only a plan which protects the city from all sources of flooding. Only plans 8, 10, 12, and 14 offer complete flood protection and hence would be socially acceptable. Plan 12, however, is not economically justified. Thus, only plans 8, 10, and 14 would satisfy the environmental, social, and economic guidelines.

52. Primary features of these three plans, each of which provides intermediate regional flood protection, are summarized as follows:

<u>Plan 8</u> - Diversion of East and Chaska Creeks around heavily developed areas of Chaska, upgrading and extension of the existing emergency levee, and installing adequate interior drainage facilities behind the levee.

<u>Plan 10</u> - Construction of four headwaters reservoirs, diversion of East and Chaska Creeks, the upgrading and extension of the existing emergency levee, and installing adequate interior drainage facilities behind the levee.

<u>Plan 14</u> - Same as plan 8 except channel improvement on East and Chaska Creeks would replace channel diversions.

Each of the alternative plans would provide a comparable high degree of flood protection at Chaska, and all three plans demonstrate economic feasibility. Table C-20 summarizes the estimated first costs, average annual costs and benefits, based on a 5 5/8-percent discount rate and a 100-year project life, and the resulting net benefits and benefit-cost ratios of each of the plans.

Table C-20 - Summary of estimated costs and benefits for alternative plans

Plan	First costs ($million)	Average annual costs ($1,000)	Average annual benefits[1] ($1,000)	Net benefits[1] ($1,000)	Benefit-cost ratio
8	9.54	579	767	188	1.3
10	12.89	765	767	2	1.0
14	10.72	611	767	143	1.2

(1) Excluding recreation benefits.

53. The three plans were then ranked on a relative scale according to how well they would satisfy the basic objectives of environmental quality, social well-being, and economic efficiency. Table C-21 presents a summary of the rating, as ranked by the Citizens Advisory Committee, Corps biologists, and Corps planners.

Table C-21 - Rating of alternative plans

Rating	Environmental quality	Social well-being	Economic feasibility
High	Plan 10	Plan 8	Plan 8
	Plan 8	Plan 10	Plan 14
Low	Plan 14	Plan 14	Plan 10

54. Plan 14, channel improvements on East and Chaska Creeks, in combination with levee upgrading and extension of the existing emergency levee, rated lowest in the environmental quality and social well-being criteria. The loss of about 2½ miles of seminatural stream setting in an urban area along East Creek, the necessary relocation of 26 homes and three businesses, and the high costs of replacing every bridge which presently crosses Chaska or East Creeks in Chaska are the major reasons for the low rating. Plan 10, which is the most costly alternative rated, would include construction of four headwaters reservoirs in the East and Chaska Creek watersheds, reduced-scale flood bypass channel, and levee improvements. Implementation of the dams would intermittently inundate about 495 acres of wetlands and narrow fringes of wooded slopes causing periodic temporary displacement of wildlife and some impacts on the lower fringes of woods and brush. However, the necessary use of shallow pools for future sediment storage would increase the value of these lands for wildlife during nonflood periods. For this reason, the environmental rating was slightly higher than for plan 8 which does not include reservoir storage and substantially higher than plan 14 in which significant permanent environmental changes would occur. Permanent deep pools could not be established in conjunction with flood protection; and, therefore, social benefits of fishing and contact water sport development would

not be expected with plan 10. At least one county road and the proposed relocation of U.S. Highway 212 would be adversely affected. The size of flood bypass channels would be minimized in comparison with plan 8. However, similar flood protection could be accomplished with plan 8 at a lesser cost and with fewer social changes than with plan 10. Thus, plan 8, flood bypass channels with levee upgrading and extension, is the most acceptable alternative since environmental changes would be within acceptable limits, the security and well-being of the people would be insured, and the benefits of such an undertaking would exceed the cost.

55. PLAN SELECTION

The above review of available alternatives indicates that structural measures offer the only feasible flood control alternative for Chaska. Of the structural plans, plan 8, channel diversions of East and Chaska Creeks, combined with levee upgrading, shows the most merit. In addition to being rated the highest on social well-being and economic feasibility and second on environmental quality, the plan is strongly supported by local interests and would provide a high degree of flood protection.

56. SCALE OF DEVELOPMENT

To permit selection of the optimum level of flood protection for the Chaska area, costs and benefits were computed for several degrees of flood protection that would be provided by varying design flood discharges for the Minnesota River and East and Chaska Creeks. The optimization analysis for the selected plan was found by using the benefits and costs of protecting Chaska from varying degrees of flooding from these sources. The plan optimization data are summarized in table C-22 and are shown graphically on plate C-5.

Table C-22 - Plan optimization summary - flood parameters at Chaska, Minn.

Flood frequency (percent)	Stage on Minnesota River (msl)	Chaska Creek discharge (cfs)	East Creek discharge (cfs)	Annual cost(3)	Annual(3) benefits	Net benefits	Benefit cost ratio
5.0	718.0	2,950	2,500	$489,000	$547,000	$58,000	1.1
3.0	719.7	3,500	3,000	515,000	628,000	113,000	1.2
1.0(1)	723.0	4,700	4,350	579,000	767,000	188,000	1.3
0.5	724.9	5,600	5,400	661,000	808,000	147,000	1.2
0.25	726.5(2)	6,800	6,500	816,000	849,000	33,000	1.0

(1) Selected level of protection and point of maximum net benefits.
(2) Equivalent to the standard project flood on the Minnesota River.
(3) Average annual costs and benefits based on a 5 5/8-percent interest rate and a 100-year project life.

57. The construction of a bridge over East Creek on Minnesota Highway 41 to replace the existing culvert has been included in the proposed plan. The bridge would be necessary to protect the East Creek flood bypass structure and channel from flood waves that could be generated by a collapse of the existing highway embankment. Three alternative methods of combating this problem were investigated. Alternative 1 considered strengthening the highway embankment to create a dam which would allow ponding to occur without danger of failure. The bypass structure and channel could be reduced in size because the increased storage could be expected to reduce flows downstream. Alternative 2 considered no modification to the highway embankment and assumes that failure would occur during a large flood. Strengthening and enlarging downstream structures would be necessary. Alternative 3 consists of a bridge on Minnesota Highway 41 over East Creek with a bypass structure and channel designed for a 1-percent chance discharge. Alternative 3 was the least costly alternative and therefore was recommended. The estimated first costs of the alternatives are shown in table C-23.

Table C-23 - First costs of East Creek flood bypass alternatives

Alternative	First cost
No. 1 - Dam at Minnesota Highway 41 with decreased size of East Creek flood bypass structure and channel due to increased storage	$4,319,000
No. 2 - No modification at Minnesota Highway 41 with downstream structures strengthened to withstand flood waves	3,665,000
No. 3 - Bridge on Minnesota Highway 41 over East Creek with bypass structure and channel designed for a 1-percent chance discharge	3,467,000

58. Consideration was given to constructing the Chaska Creek diversion to provide protection from the standard project flood. The first cost of this plan increased the cost of the diversion about 2½ times over that of the proposed scale of development. In addition, the increase in average annual costs exceeded the expected increase in average annual benefits by 4 times. Although added security to the citizens of Chaska would result, the cost to provide this degree of protection from Chaska Creek flooding was considered excessive.

59. An optimum relationship between costs and benefits exists when protection is provided for floods from East and Chaska Creeks and the Minnesota River, having an average frequency of occurrence in the order of once in 100 years. It was considered impracticable to increase the design capacity beyond intermediate regional flood protection since large additional expenditures for bridge modifications, land, and residence relocation or purchase would be necessary although such measures could be economically justified. Therefore, a plan providing intermediate regional flood protection was selected. Furthermore, the levee protecting Chaska from Minnesota River flooding is designed to contain the standard project flood within the freeboard range, although emergency measures would be required and could be effectively employed to provide additional levee closures required by floods greater than the intermediate regional flood.

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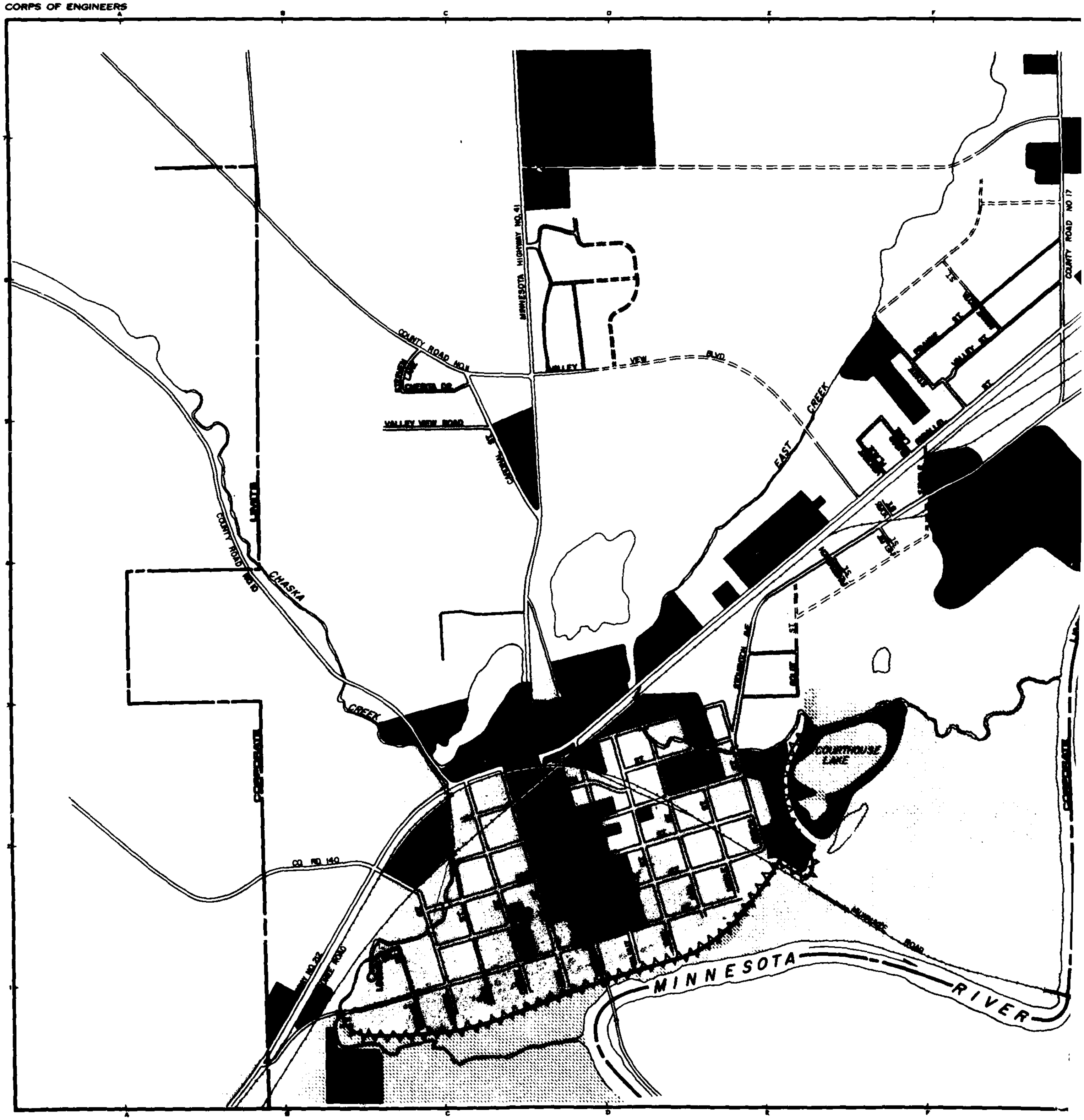

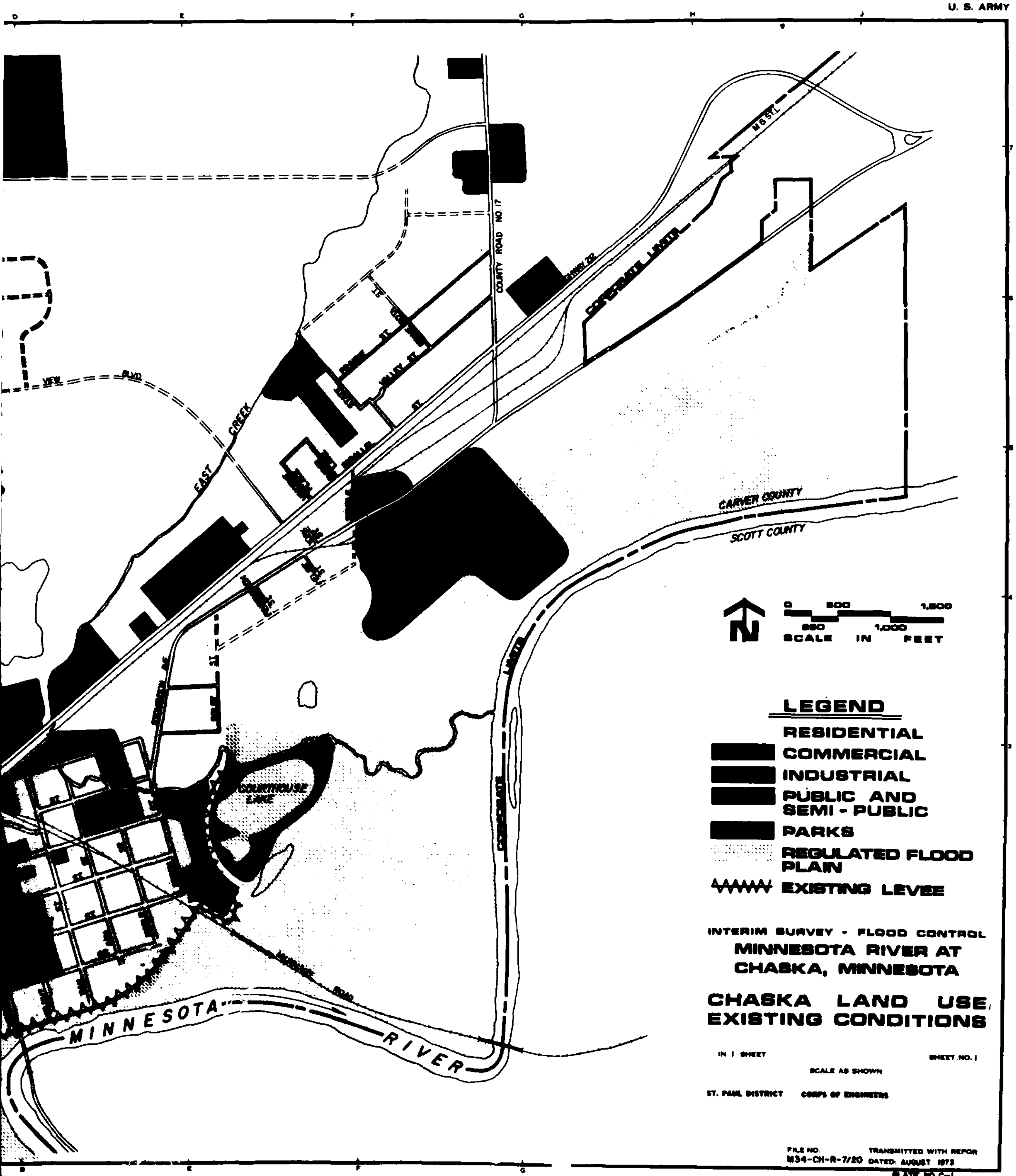
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REGULATED FLOOD PLAIN
EXISTING LEVEE
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
CHASKA LAND USE, EXISTING CONDITIONS
IN 1 SHEET
SHEET NO. 1
SCALE AS SHOWN
ST. PAUL DISTRICT CORPS OF ENGINEERS
FILE NO. M34-CH-R-7/20
TRANSMITTED WITH REPOR DATED: AUGUST 1973
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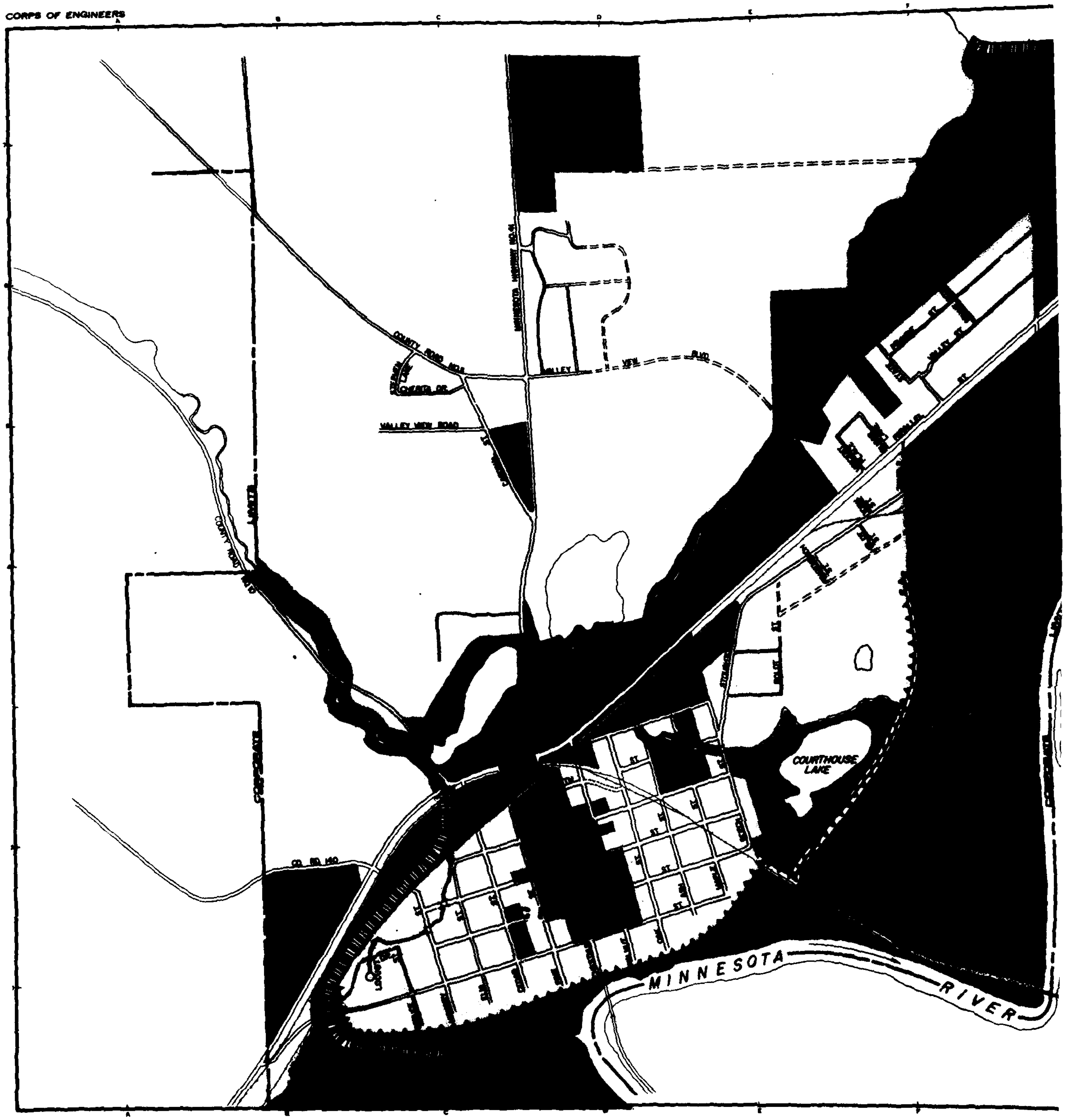
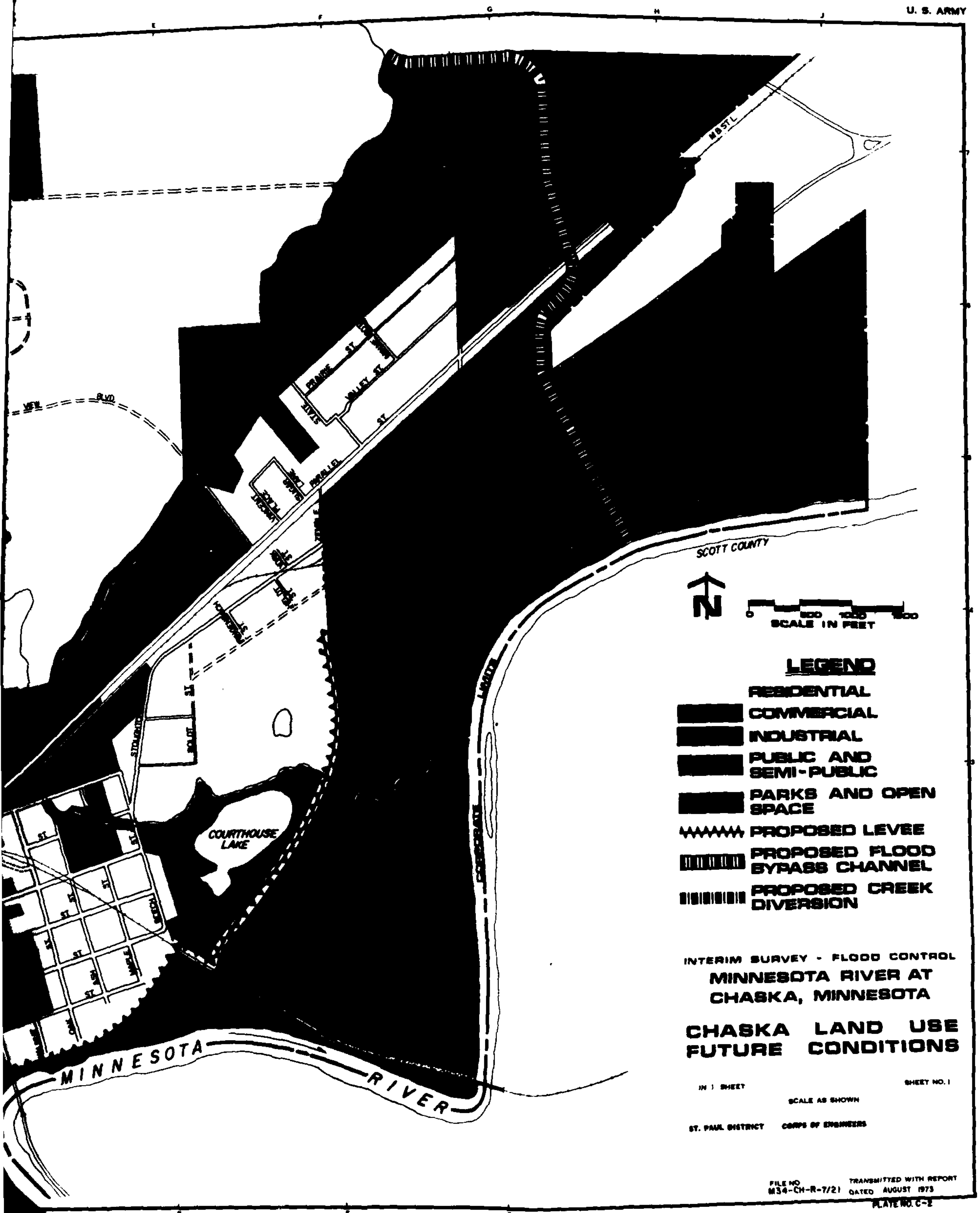
CORPS OF ENGINEERS

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PUBLIC AND SEMI-PUBLIC
PARKS AND OPEN SPACE
PROPOSED LEVEE
PROPOSED FLOOD BYPASS CHANNEL
PROPOSED CREEK DIVERSION
COURTHOUSE LAKE
MINNESOTA RIVER
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT
CHASKA, MINNESOTA
CHASKA LAND USE
FUTURE CONDITIONS
IN 1 SHEET
SHEET NO. 1
SCALE AS SHOWN
ST. PAUL DISTRICT
CORPS OF ENGINEERS
FILE NO
M34-CH-R-7/21
TRANSMITTED WITH REPORT
DATED AUGUST 1973

PLATE NO. C-2

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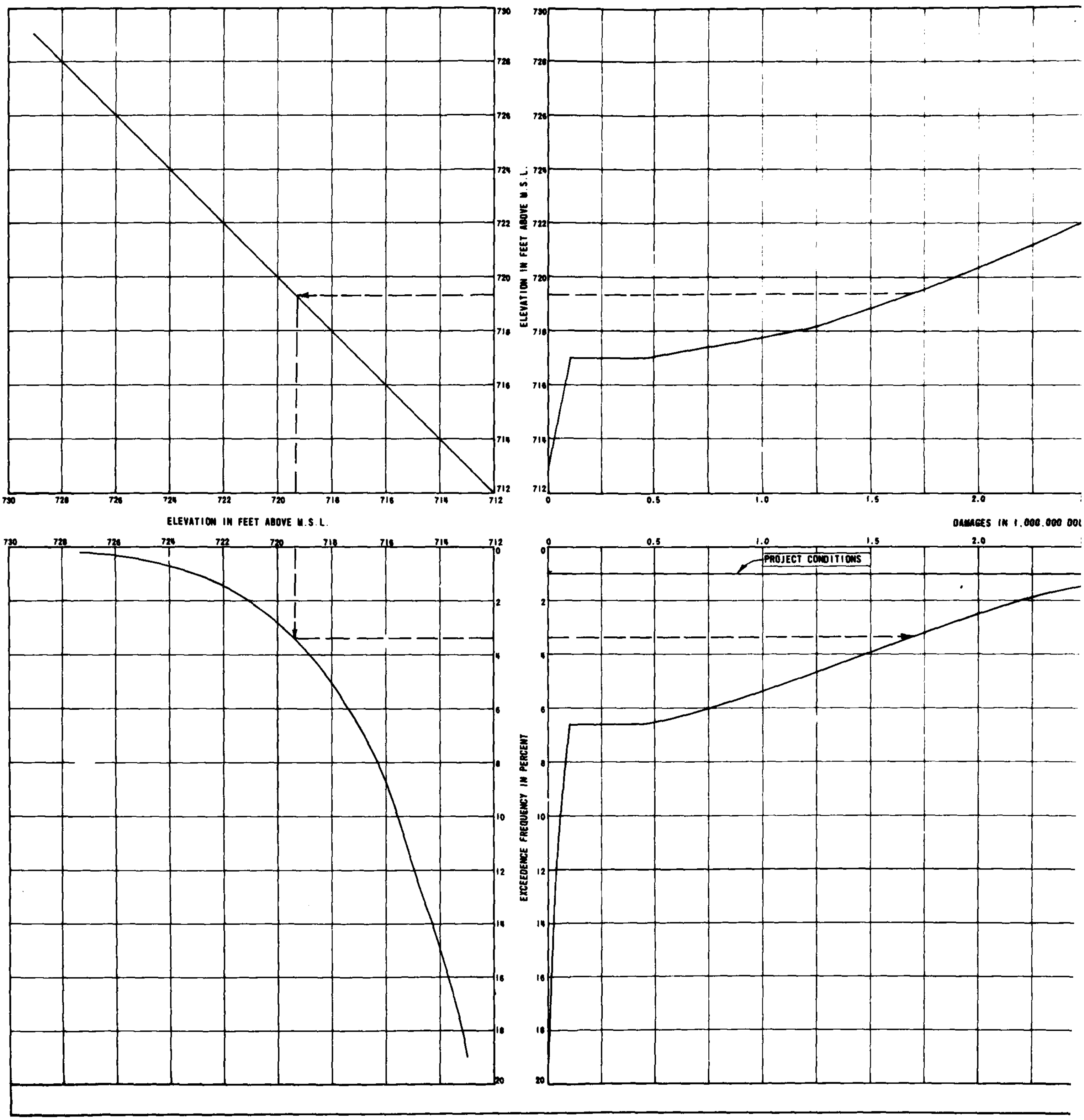
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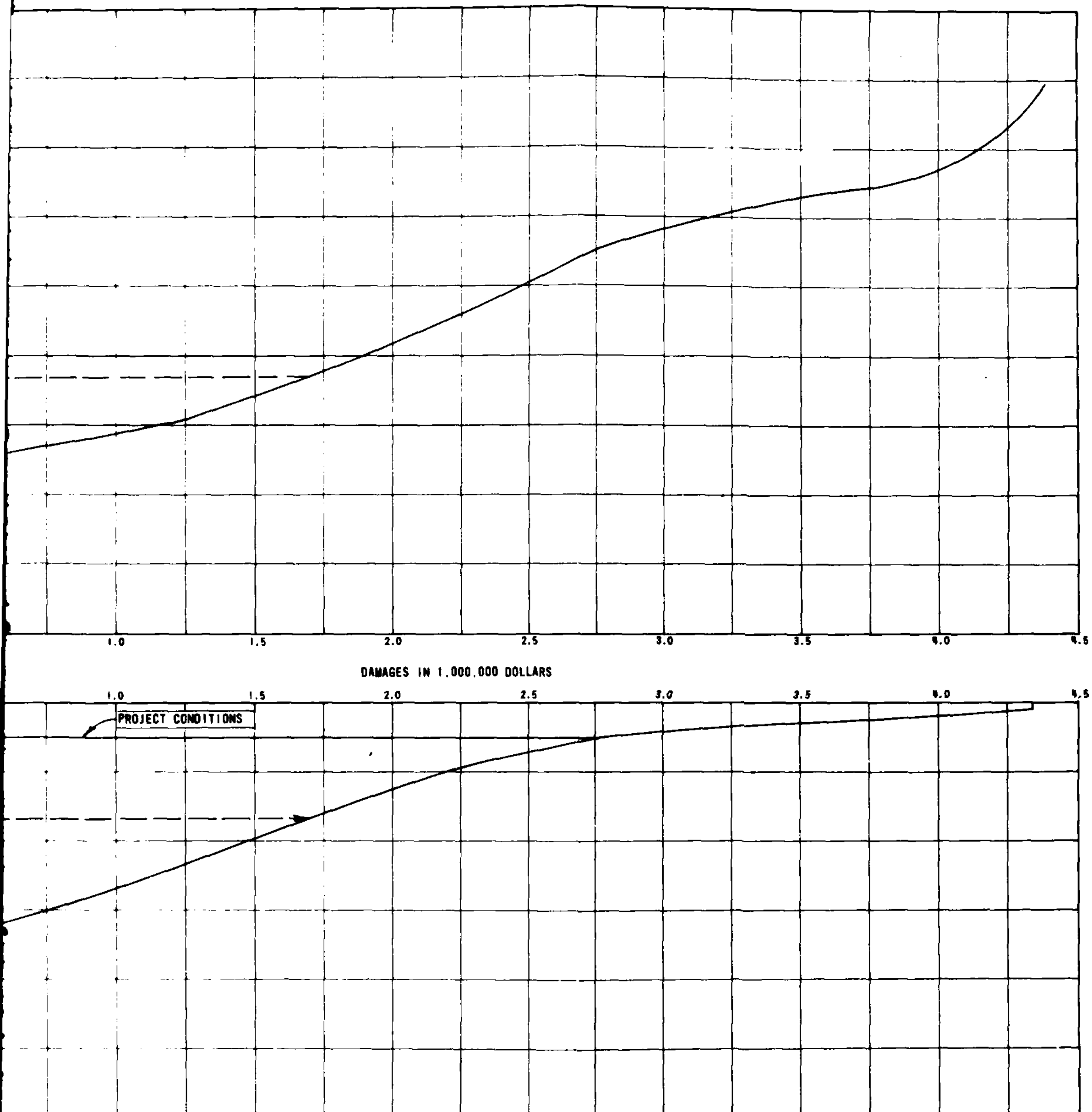


AVERAGE ANNUAL DAMAGE	
EXISTING	$129,600
WITH PROJECT	$41,600
BENEFIT	$88,000

FEBRUARY 1973 PRICES - 1973 CONDITIONS

INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT
CHASKA, MINNESOTA

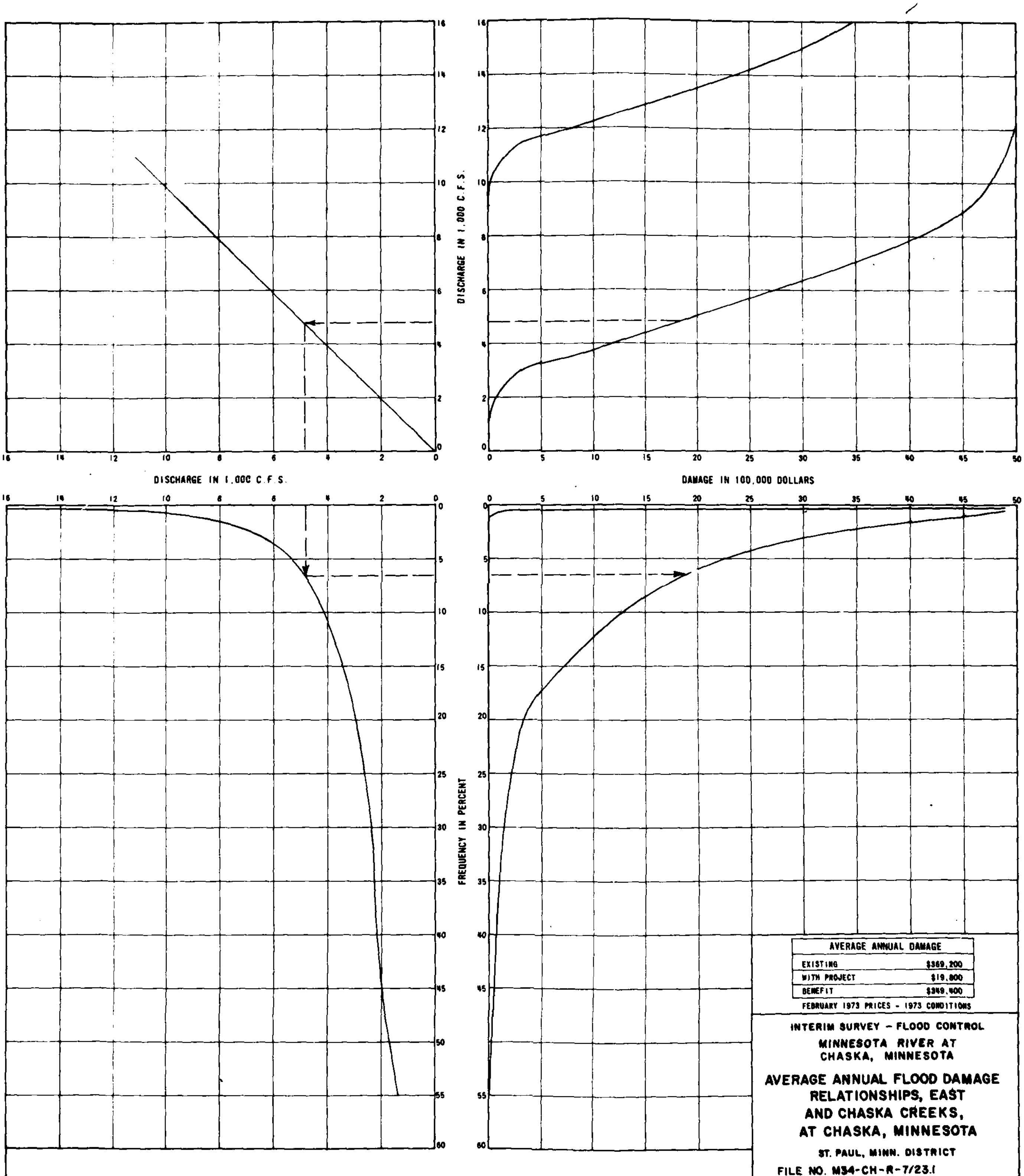
AVERAGE ANNUAL FLOOD DAMAGE RELATIONSHIPS, MINNESOTA RIVER AT CHASKA, MINNESOTA

ST. PAUL, MINN. DISTRICT

FILE NO. M34-CH-R-7/22.1

PLATE C-3

2



AVERAGE ANNUAL DAMAGE	
EXISTING	$369,200
WITH PROJECT	$19,800
BENEFIT	$349,400

FEBRUARY 1973 PRICES - 1973 CONDITIONS

INTERIM SURVEY – FLOOD CONTROL

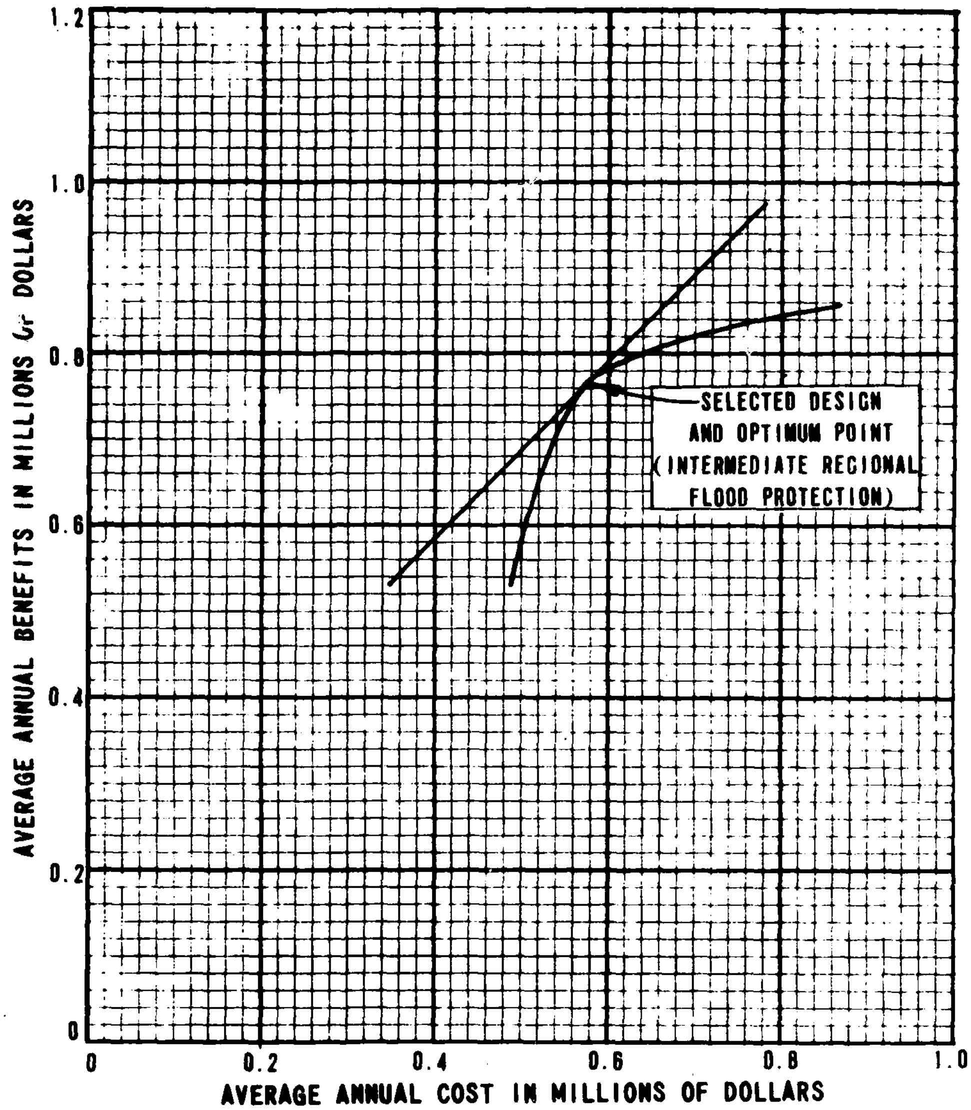
MINNESOTA RIVER AT
CHASKA, MINNESOTA

AVERAGE ANNUAL FLOOD DAMAGE RELATIONSHIPS, EAST AND CHASKA CREEKS, AT CHASKA, MINNESOTA

ST. PAUL, MINN. DISTRICT

FILE NO. M34-CH-R-7/23.1

PLATE C-4



INTERIM SURVEY - FLOOD CONTROL

MINNESOTA RIVER AT CHASKA, MINNESOTA

BENEFIT COST RELATION AT CHASKA, MINNESOTA

ST. PAUL, MINN. DISTRICT

FILE NO. M34-CH-R-7/24.1

PLATE C-5

APPENDIX D

COST ESTIMATES

BASIS FOR COST ESTIMATES

1. Estimated costs contained within this appendix are based on unit prices adjusted to reflect average bid prices received on comparable work by the St. Paul District. An allowance of 20 percent for contingencies is included in the estimated costs.

FIRST COSTS

2. The detailed estimate of first costs for the work recommended by this report is given in table D-1 with the costs shown based on February 1973 price levels. The estimated cost of lands is based on appraisal data obtained from office studies.

Table D-1 - Detailed estimate of first costs

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs				
Relocations				
Railroads				
Construct bridge, station 29+08 (1)	Job	Sum	-	$168,000
Construct bridge, station 16+75 (2)	Job	Sum	-	195,000
Replace bridge, station 41+70 (2)	Job	Sum	-	45,000
Remove track, station 29+00 to 30+00 (1)	LF	400	$3.00	1,200
Contingencies				81,800
Total railroads				491,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Relocations (cont)				
Bridge removal and protection				
Remove culvert on Highway 41(1)	Job	Sum	-	$22,000
Remove bridge, station 63+00(1)	Job	Sum	-	2,000
Remove First Street Bridge(2)	Job	Sum	-	5,000
Protection, Highway 212 bridge, station 42+40(2)	Job	Sum	-	5,000
Contingencies				7,000
Total bridge removal and protection				41,000
Total relocations				532,000
Channels				
Excavation, common	CY	395,000	$1.00	395,000
Grubbing and clearing	Acre	9.0	1,000.00	9,000
Semicompacted fill	CY	44,000	2.00	88,000
Riprap	CY	52,000	15.00	780,000
Filter gravel	CY	29,500	8.00	236,000
Sand filter(2)	CY	500	2.00	1,000
Drop structure, station 2+00(1)	Job	Sum	-	45,000
Drop structure, station 16+20(1)	Job	Sum	-	150,000
Drop structure, station 55+00(1)	Job	Sum	-	155,000
Drop structure, station 2+00(2)	Job	Sum	-	51,000
Drop structure, station 41+90(2)	Job	Sum	-	110,000
Drop structure, station 46+70(2)	Job	Sum		45,000
Tributary inlet structure station 31+00(2)	Job	Sum	-	27,000
Low-flow pipe, 48-inch(1)	LF	150	50.00	7,500
Low-flow control gate and structure(1)	Job	Sum	-	12,000
Dewatering channel(2)	LF	680	50.00	34,000
Concrete channel(2)	LF	400	460.00	184,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Channels (cont)				
Seeding, topsoil and finishing	Acre	5.0	$2,000.00	$10,000
Landscaping	Job	Sum	-	45,000
Safety fencing	LF	1,600	8.00	12,800
Contingencies				479,700
Total channels				2,877,000
Channel utilities				
Sanitary sewer force main relocation, station 16+90(1)	Job	Sum	-	5,000
Sanitary sewer siphon, station 62+00(1)	Job	Sum	-	10,000
Sanitary sewer siphon, station 31+40(2)	Job	Sum	-	7,000
Contingencies				4,000
Total channel utilities				26,000
Levees				
Levee work				
Grubbing and clearing	Acre	6.0	1,000.00	6,000
Remove interceptor sewer, 8-inch VCP, section 2	LF	1,700	1.75	2,975
Remove manholes, section 2	Ea	5	50.00	250
Remove 36-inch RCP from existing levee, section 2	LF	36	3.00	108
Remove headwall, section 2	Job	Sum	-	250
Remove 16-inch steel pipe from top of existing levee, section 2	Job	Sum	-	150
Remove concrete flume, section 2	Job	Sum	-	200
Remove interceptor sewer, 8-inch VCP, section 3	LF	500	1.75	875
Plug 8-inch CIR force main, section 3	LF	1,400	2.00	2,800

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
<u>Federal first costs</u> (cont)				
<u>Levees</u> (cont)				
<u>Levee work</u> (cont)				
Remove 36-inch RCP, section 3	LF	96	$3.00	$288
Remove headwall, section 3	Job	Sum	-	250
Remove 16-inch steel pipe from top of existing levee, section 3	Job	Sum	-	150
Remove concrete flume, section 3	Job	Sum	-	250
Stripping	CY	17,400	1.00	17,400
Inspection trench	CY	20,800	1.50	31,200
Levee fill	CY	187,500	0.30	56,250
Levee fill	CY	5,400	1.00	5,400
Levee fill	CY	145,900	2.00	291,800
Filter	CY	3,790	8.00	30,320
Riprap	CY	7,580	15.00	113,700
Landscaping	Job	Sum	-	40,000
Topsoil	CY	10,360	2.00	20,720
Seeding	Acre	19.3	500.00	9,650
Contingencies				126,014
Total levee work				757,000
<u>Closures</u>				
No. 1 (stop log closure with sheet-pile seepage barrier on Milwaukee Road RR)	Job	Sum	-	26,500
No. 2 (sandbag closure on Highway 41)	Job	Sum	-	1,000
No. 3 (sandbag closure on First Street)	Job	Sum	-	1,000
No. 4 (seepage barrier, Mpls & St. Louis RR)	Job	Sum	-	1,500
Contingencies				6,000
Total closures				36,000

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Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Levees (cont)				
Drainage facilities				
Outlet A - Chaska Creek				
RCP, 54-inch, class IV	LF	200	$220.00	$44,000
Gate well	Job	Sum	-	9,000
Sluice gate, 54-inch, with stand	Each	1	7,000.00	7,000
Diaphragms	Each	5	255.00	1,275
Energy dissipator	Each	1	19,000.00	19,000
Contingencies				16,725
Total outlet A				97,000
Outlet B - Elm Street				
RCP, 54-inch, class III	LF	140	65.00	9,100
Gate well	Job	Sum	-	15,000
Sluice gate, 54-inch with stand	Each	1	7,000.00	7,000
Diaphragms	Each	5	255.00	1,275
Energy dissipator	Each	1	19,000.00	19,000
RCP, 24-inch, class III	LF	200	30.00	6,000
RCP, 30-inch, class III	LF	500	35.00	17,500
RCP, 36-inch, class III	LF	1,000	41.00	41,000
RCP, 42-inch, class III	LF	800	48.00	38,400
RCP, 48-inch, class III	LF	800	53.00	42,400
RC manholes with catch basins	Each	10	800.00	8,000
Install gate well on existing 84-inch RCP at Chestnut Street	Job	Sum	-	12,000
Sluice gate with stand 84-inch	Each	1	9,600.00	9,600
Contingencies				45,725
Total outlet B				272,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Levees (cont)				
Drainage facilities (cont)				
Outlet C - Maple Street				
RCP, 72-inch class III	LF	140	$95.00	$13,300
Gate well	Job	Sum	-	19,000
Sluice gate, 72-inch with stand	Each	1	9,000.00	9,000
Diaphragms	Each	5	340.00	1,700
Energy dissipator	Each	1	25,000.00	25,000
RCP, 30-inch, class III	LF	650	36.50	23,725
RCP, 42-inch, class III	LF	150	51.00	7,650
RCP, 54-inch, class III	LF	400	64.00	25,600
RCP, 60-inch, class III	LF	400	70.00	28,000
RCP, 66-inch, class III	LF	400	85.00	34,000
RC manholes, with catch basins	Each	8	800.00	6,400
Install gate well on existing 18-inch RCP on Walnut Street	Job	Sum	-	5,000
Sluice gate, 18-inch with stand	Each	1	2,250.00	2,250
Diaphragms for existing 18-inch RCP	Each	5	80.00	400
Modify inlet and outlet headwall structures at each end of 18-inch RCP for proposed levee	Job	Sum	-	10,000
Contingencies				41,975
Total outlet C				253,000
Outlet D - East Creek				
RCP, 108-inch, class IV	LF	320	205.00	65,600
Gate well	Job	Sum	-	24,000
Sluice gate, 108-inch with stand	Each	2	8,000.00	16,000
Diaphragms	Each	6	640.00	3,840
Energy dissipator	Each	1	38,000.00	38,000
Interceptor ditch	CY	2,000	2.00	4,000
Gate well for 21-inch CIP	Job	Sum	-	9,700
Sluice gate, 21-inch	Each	1	1,100.00	1,100
Contingencies				32,760
Total Outlet D				195,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Levees (cont)				
Drainage facilities (cont)				
Control structure E at Courthouse Lake				
RCP 72-inch, class III	LF	100	$70.00	$7,000
Gate well	Job	Sum	-	9,200
Sluice gate, 72-inch with stand	Each	1	9,000.00	9,000
RCP end sections	Each	2	500.00	1,000
Diaphragms	Each	3	425.00	1,275
Contingencies				5,525
Total control structure E				33,000
Outlet F near Court House				
RCP,42-inch, class IV	LF	100	31.00	3,100
RC manhole, with catch basin	Each	1	800.00	800
RC end section	Each	1	200.00	200
Flap gate, 42-inch complete	Each	1	4,300.00	4,300
Contingencies				1,600
Total outlet F				10,000
Total drainage facilities				860,000
Total levees				1,653,000
Relief well system				
Relief well	Job	Sum	-	350,000
Contingencies				70,000
Total relief well system				420,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Federal first costs (cont)				
Pumping plants				
Chaska Creek pump station	Job	Sum	-	$200,000
Elm Street pump station	Job	Sum	-	305,000
Maple Street pump station	Job	Sum	-	320,000
East Creek pump station	Job	Sum	-	330,000
Contingencies				231,000
Total pumping plants				1,386,000
Total construction cost				6,894,000
Total engineering and design				689,000
Total supervision and administration				413,000
Total Federal recreational facilities cost				18,000
Total Federal first costs				8,014,000
Non-Federal first costs				
Lands and damages				
Lands and rights-of-way costs				399,000
Acquisition costs				35,000
Contingencies				87,000
Total lands and damages				521,000
Relocations				
Bridge modifications				
Construct Highway 41 bridge(4)	Job	Sum	-	191,000
Construct Stoughton Avenue Bridge(1)	Job	Sum	-	115,000
Construct U.S. Highway 212 bridge(1)	Job	Sum	-	80,000
Construct County Highway 17 bridge(1)	Job	Sum	-	110,000
Replace First Street Bridge(2)	Job	Sum	-	85,000
Construct Hickory Street Bridge(2)	Job	Sum	-	94,000
Replace private driveway bridge(2)	Job	Sum	-	18,000
Engineering and contingencies				208,000
Total bridge modifications				901,000

Table D-1 - Detailed estimate of first costs (cont)

Item	Unit	Quantity	Unit cost	Total estimated cost
Non-Federal first costs (cont)				
Relocations (cont)				
Utilities				
Relocate buried telephone cable, station 31+00(1)	Job	Sum	-	$3,000
Construct 12-inch water main bridge crossing, station 56+90(1)	LF	140	$50.00	7,000
Relocate Brandendale utility conduit, station 63+00(1)	Job	Sum	-	10,000
Construct 6-inch water main bridge crossing, station 31+40(2)	LF	100	40.00	4,000
Relocate utility poles(2)	Job	Sum	-	7,000
Install 8-inch VCP sewer section 1(3)	LF	2,200	5.50	12,100
Install manholes, section 1(3)	Each	5	800.00	4,000
Install 8-inch CIP force main(3)	LF	1,400	10.50	14,700
Install 8-inch CI gate valve(3)	Each	1	350.00	350
Relocate hydrant(3)	Each	1	1,000.00	1,000
Relocate utility lines(3)	Job	Sum	-	5,000
Engineering and contingencies				20,850
Total utilities				89,000
Total relocations				990,000
Non-Federal share of recreation costs				18,000
Total non-Federal first costs				1,529,000
Total first costs				
Federal first cost				8,014,000
Non-Federal first costs				1,529,000
Total first costs				9,543,000

(1) East Creek flood bypass.
(2) Chaska Creek diversion.
(3) Minnesota River levee.
(4) Construction of a bridge to pass East Creek flood flows is less costly than increasing the size of the flood bypass structure to contain flood waves which may result if the Highway 41 embankment fails during a flood.

ESTIMATE OF ANNUAL CHARGES

3. Annual charges for the proposed improvements are based on an interest rate of 5 5/8 percent and an amortization period of 100 years. Included in the annual charges is an allowance for interest during an assumed 2-year construction period. Maintenance and operation of the proposed improvement are based on cost data available for similar work throughout the country. Estimates of the average annual maintenance, operation and replacement costs are shown in table D-2. Table D-3 summarizes the estimated annual charges for the flood protection plan at Chaska.

Table D-2 - Estimates of annual maintenance, operation, and replacement costs

Item	Annual cost
Replace pumps at four pumping stations(1)	$11,000
Annual power charges	300
Levee maintenance	2,000
Channel maintenance	2,700
Pumping plant operation	1,000
Total	17,000

(1) Amortized costs based on 35-year life.

Table D-3 - Estimated annual charges

Item	Annual charges
Total first cost	$9,543,000
Interest during construction	389,000
Total economic investment	9,932,000
Interest and amortization(1)	561,000
Operation, maintenance, and major replacements	17,000
Recreation trail maintenance	1,000
Total annual charges	579,000

(1) Interest and amortization for 100-year life at 5 5/8-percent interest rate = 0.05649.

APPENDIX E
FLOODPLAIN REGULATION

PURPOSE AND SCOPE

1. The purpose of this appendix is to familiarize the officials of the city of Chaska with floodplain management measures available for reducing flood losses and of their relationship to existing and future loss potential. The combined solutions involving channel diversion, flood bypass channel, levees, land-use controls, and other measures are all required to insure proper management of the floodplain and to minimize flood losses in the future. This appendix describes the various measures which can be accomplished by local governments to control future land use and developments as a means of reducing the flood threat for the residual floodplain not afforded flood protection.

AVAILABLE DATA

2. Information on streamflow records, past floods, and flood frequencies is provided in the main report and appendix B, Hydrology, Hydraulics, and Interior Drainage. The damages resulting from floods and the effect on development plans are discussed in appendix C, Flood Damage and Benefit Analyses and Plan Formulation.

METHODS OF FLOOD DAMAGE REDUCTION

3. Equally as important as structural measures in preventing future flood damages are the land-use controls and other measures which can be implemented by local governments and individuals to guide future floodplain developments in such a manner as to lessen the damaging effects of floods. The Minnesota State Floodplain Management Act (Minnesota Statute, Chapter 104) of May 1969 provides State coordination and assistance to local governmental units in floodplain management; encourages local governmental units to adopt, enforce, and administer sound floodplain management ordinances; and provides the commissioner of natural resources with authority necessary to carry out a floodplain management program for the State and to coordinate Federal, State, and local floodplain management activities in the State. Before local ordinances can be adopted, technical data must be developed for delineation of floodplains and floodways along watercourses (see plate E-1). The ordinances are designed to include provision for preservation of the capacity of the floodplain to carry and discharge intermediate regional floods, minimization of flood hazards, and regulation of the use of floodplain land. Floodplain management ordinances and subsequent modifications are subject to approval of the commissioner of natural resources.

4. The act requires that the commissioner shall promulgate rules and regulations covering:

a. Criteria for determining the floodplain uses which may be permitted without creating an unreasonable public hazard or unduly restricting the capacity of the floodplain to carry and discharge the regional floods.

b. Variance procedures.

c. Criteria for alternative or supplemental floodplain management measures such as flood proofing, subdivision regulations, building codes, sanitary regulations, and flood warning systems.

d. Due consideration to the needs of industry whose business requires that it be located within a floodplain.

For these controls to be effective, public understanding of the general flood problem, the degree of risk, and the methods that can be used to control use of the land is necessary. The various methods of regulating floodplain land use and development and other possible means of reducing or preventing future flood damages are described in subsequent paragraphs.

5. The studies for this report included a comparison of several alternative means of solving the flood and other water-related problems of the East and Chaska Creek watersheds, and of the flood prone areas of Chaska within the Minnesota River floodplain. Based on these studies, a flood bypass channel on East Creek, channel diversion on Chaska Creek, levee upgrade along the Minnesota River, together with floodplain regulations in accordance with State law in the intermediate regional floodplain which remains after construction of the proposed structural measures represent the most practical and economical water resources development and management plan. The residual floodplain after proposed project development is shown on plate 3 of the main report and the corresponding water surface elevations are shown on plate E-4.

6. The proposed plan of improvement and its beneficial effect on reducing flood stages and damages are described in the main report and in other appendixes.

CONTROL OVER THE LAND

7. GENERAL

In a sound floodplain management program prevention of future flood damages by land-use controls and other measures which can be implemented by local governments or individuals is equally as important as structural measures in lessening the damaging effects of floods. Floodplain regulations imply the adoption and use of

legal tools by communities with which to control the extent and types of future development which would be permitted in the floodplains. For these controls to be effective, public understanding of the general flood problem, the degree of risk, and the methods that can be used to control use of the land is necessary. The various means of regulating floodplain land use and development and other possible means of reducing or preventing future flood damage are described in subsequent paragraphs.

8. DESIGNATED FLOODWAYS AND ENCROACHMENT LINES

A designated floodway is the area of channel and those portions of the floodplain adjoining the channel which are reasonably required to carry floodwaters. Encroachment lines are the lateral boundaries of the floodway, one on each side of the river. In general, neither construction nor land filling should be permitted between these lines if these works would interfere with the passage of floodwaters as specified in the State floodplain regulations.

9. ZONING

Zoning is the legal tool that is used to implement and enforce the detailed plans resulting from the planning program. It is used by communities, counties, and agencies of the State to control and direct the use and development of land and property within their jurisdiction. Zoning insures the safekeeping of property for public health and welfare and the best use of available land. Division of communities into various zones should be the result of a comprehensive planning program for the entire area. Designated floodways may be zoned for the purpose of passing floodwaters and for other limited uses that do not conflict with that primary purpose. The ordinance may also establish regulations for the floodplain areas outside of the floodway. These include designating elevations below which certain types of development cannot be constructed.

10. SUBDIVISION REGULATIONS

A subdivision can be defined as a tract of land divided into lots for the purpose of either sale or building development. Subdivision regulations are used by local governments to specify the manner in which land may be divided. These regulations may state the required width of streets, requirements for curbs and gutters, size of lots, elevation of land, freedom from flooding, size of floodways, and other points pertinent to the welfare of the community. Not only can public health and welfare benefit, but various municipal costs such as maintenance of streets and utilities can be reduced during flood periods. Subdivision regulations provide an efficient means of controlling construction in presently undeveloped floodplain areas. The following typical provisions which could be added to regulations would be helpful to flood damage prevention:

a. Show extent of the floodplain on subdivision maps.

b. Show floodway limits or encroachment lines.

c. Prohibit fill in the floodway that would restrict flow.

d. Require that subdivision roads be above the elevation of a selected flood level.

e. Require that each lot contain a building site with an elevation above a selected flood level.

11. BUILDING CODES

A building code is a set of regulations adopted by a local governing body. The code sets forth standards for the construction of buildings and other structures for the purpose of protecting the health, safety, and general welfare of the public. A well-written and properly enforced building code can effectively reduce damages to buildings in the floodplain. A few of the requirements which should be specified in a building code to reduce flood damages are:

a. Prevent flotation of buildings from their foundations by requiring proper anchorage.

b. Establish basement elevations and minimum first-floor elevations consistent with potential floods.

c. Require structural strength to withstand either water pressure or high velocity of flowing water.

d. Restrict the use of materials which deteriorate rapidly when exposed to water.

e. Prohibit equipment that might be hazardous to life when submerged, such as chemical storage, boilers, or electrical equipment.

12. DEVELOPMENT POLICIES

Wise day-to-day policy and action decisions to prevent construction of streets and utility systems in undesirable areas will deter development in floodplains. Street improvements, schools, and other public facilities located elsewhere discourage floodplain exploitation and encourage development toward higher ground.

FLOOD PROOFING

13. Flood proofing is a combination of structural changes and adjustments to properties subject to flooding primarily for the reduction or elimination of flood damages. Although it is more simply and economically applied to new construction, flood proofing is also applicable to existing facilities. It has promise in one or more of the following situations.

a. Where moderate flooding with low stage, low velocity, and short duration is experienced.

b. Where the traditional type of flood protection is not feasible.

c. Where individuals desire to solve their flood problems without collective action, or where collective action is not possible.

d. Where activities dependent on river locations need some degree of protection.

e. Where a resource manager desires a higher degree of protection than that which is provided by a flood control project.

Many different flood proofing measures have been recognized and studied. The names given most of them are self-explanatory. Included in those measures are the following items:

Seepage control	Watertight caps	Appliance protection
Sewer adjustment	Proper anchorage	Utility adjustments
Permanent closure	Underpinning	Roadbed protection
Openings protected	Timber treatment	Elevation or raising
Interiors protected	Deliberate flooding	Temporary removal
Protective coverings	Structural design	Rescheduling
Fire protection	Reorganized use	Proper salvage

A general sketch showing some flood proofing techniques is shown on plate E-2. The following paragraphs describe in more detail some of the more applicable measures available for flood proofing existing residential properties.

14. Seepage control, because of the pervious foundation soils at Chaska, will remain a problem even with the proposed flood control works in place. However, foundation walls can be made watertight to minimize water infiltration through cracks and crevices in the walls. In buildings under construction, this can be accomplished through the use of waterproof membranes

and seals. Construction joints can be protected by the use of a neoprene or similar waterstop. Existing masonry or stone foundations are more difficult to waterproof, particularly if the mortar joints have deteriorated with age. Sealing of walls to prevent seepage can be accomplished in many cases, however, by coating them, preferably on the exterior, with hydraulic cement, epoxy paint, or other similar waterproofing materials. It must be recognized that sealing and waterproofing of walls increases the hydraulic forces acting on the walls unless the drainage through the walls which is afforded by the cracks and crevices prior to sealing is provided by other means. Sometimes the wisest course would be to permit the seepage through the wall and then control it by a floor drain and sump pump. Existing cracks and leaks in walls sometimes can be the most practical form of drainage to relieve pressure. In some cases this drainage can be supplemented by holes drilled through the walls. Structural and hydraulic analyses of alternative designs and associated cost estimates will enable the designer to choose the most suitable means of controlling seepage at a given building. A sump and pump system can be employed to help protect the subsurface part of a building. The pump could be designed to accept storm and seepage flows and pump them to a point above the floodwaters. The sump should be open to the soil at the bottom and to atmospheric pressure at the top within the basement. This would provide a fail-safe feature, in that power or pump failure would allow water to flood the basement and thereby tend to balance the outside flood induced pressures upon the basement walls and floor slab. As an alternative, a prearranged program of deliberate flooding with clean water could be employed to minimize the cost of cleanup after a flood.

15. Regarding sewer backup, most existing subdrains, whether connected to sewage systems or not, are subject to backflow and high pressures during floods. Since these high pressures could burst the usually encountered clay pipe subdrains and endanger basement walls and floors, some device such as a gate valve must be provided for protecting or isolating the subdrains around the building from these high pressures. There are several alternative methods for controlling backflow through sewers. One method would be to install a main valve at a location where the sewer is strong enough to resist the flood induced pressure and where all possible reverse flows can be stopped. See locations A and B in figure E-1 on plate E-3. This valve should be designed to accommodate grit and other materials which could lodge in it. If the pipe is of sufficient strength, an alternative would be to install separate valves on all basement fixtures and floor drains (figure E-1). These valves could be inflatable

plug. Valves designed for low pressure (20 pounds per square inch and less) could be installed in drain lines of fixtures which are below design water levels. In either of the above alternatives, it would be necessary to provide adequate sump pumps to handle any leakage. Figure E-2 shown on plate E-3 presents another alternative for controlling sewer backup. This alternative provides for outletting all floor drainage, appliance drainage, drain tile flow, and any seepage that might enter the building, to a sump pump. The pump would lift the drainage up to an elevation above the design flood on a permanent basis. By thus eliminating all gravity sewer drains, the problem of flooding backflow can be eliminated and a subsurface area permitted to function during floods.

16. Flood proofing of all existing buildings is not practical since most structures are not designed to withstand the high heads involved. Raising the flood-prone structures several feet, when physically possible, and removing structures which are not feasible to raise would entail costs exceeding $19 million. In addition, the "perched" appearance of the raised buildings inherent in the flood proofing process would be aesthetically unappealing and socially unacceptable.

17. A useful guide, "Introduction to Flood Proofing," prepared by the Center for Urban Studies, University of Chicago, under the sponsorship of the Corps of Engineers, is available upon request. It presents many helpful suggestions and briefly outlines and illustrates the possibilities of this approach. Another guide entitled "Recommended Riverine Flood-Proofing Regulations" currently being prepared by the Corps of Engineers will also be available upon request when completed.

FLOOD FORECASTING

18. Because of the highly technical nature of the work and the interstate factors that must be considered, the Federal Government has provided leadership in developing and operating the major flood forecasting system. The National Oceanic and Atmospheric Administration, National Weather Service, Department of Commerce, provides flood warning service for the State of Minnesota. A flood forecasting and flood warning system presently available for the Minnesota River through the National Weather Service and the St. Paul District, Corps of Engineers provides Chaska city officials and local news media with reliable flood forecasts and warnings. However, little or no warning could be given if intense rainfall caused a flash flood on East and Chaska Creeks. Emergency protective

measures to extend existing levees and provide portable pumps could be done to protect against Minnesota River flooding but numerous fixed improvements including homes, businesses, schools, utilities, and transportation facilities would remain subject to damage from flash flooding on the creeks.

TEMPORARY EVACUATION

19. Temporary evacuation of persons and property from the path of floodwaters is another important part in reducing flood losses. When a flood is expected:

a. Buildings can be evacuated.

b. Materials can be either raised above floodwaters or removed to higher ground.

c. Emergency protective measures can be undertaken.

d. Flood fighting and relief agencies can be activated.

PERMANENT EVACUATION

20. Permanent evacuation of developed areas subject to inundation involves the acquisition of lands by purchase (through the exercise of the powers of eminent domain, if necessary), the removal of improvements, and the relocation of the population from such areas. Lands acquired in this manner could be used for agriculture, parks, or other purposes that would not interfere with flood flows or result in material damage from floods.

OPEN SPACES

21. Great emphasis is being placed on the growing need for vastly increased areas for recreational and other open-space uses. Areas adjacent to streams and other bodies of water have a natural attraction and are readily adaptable to recreation and open areas. Parks, playgrounds, and picnic areas can utilize lands which would not be suitable for facilities requiring permanent structures. A number of localities throughout the country are using floodplains for such purposes and are reaping secondary benefits from flood damage prevention. Federal grants are made to assist communities in acquiring such open spaces when linked with a program of comprehensive planning. A green space area ultimately planned as part of an environmental appreciation trail system is proposed in a section of the residual floodplain area of Chaska as part of the city's open-space program. The remainder of the residual floodplain would be regulated in accordance with State law.

URBAN REDEVELOPMENT (RENEWAL)

22. Urban renewal can be used in flood-blighted areas that are a drain on the economic life and welfare of the community and do not lend themselves to other methods of regulation and control. The Federal Urban Renewal Program provides substantial assistance to municipalities burdened with such conditions. A redevelopment program should include flood control works where appropriate and necessary as well as setting aside the lowest floodplain areas for parks, open spaces, and other uses not subject to substantial flood damages. Public parking areas may be designated provided adequate regulations or precautions are established. To minimize flood damages, the higher areas can be used for new structures.

WARNING SIGNS

23. A method which may be used to discourage development is the erection of flood warning signs in the floodplain area, or the prominent posting of previous high-water levels. These signs carry no enforcement but simply serve to inform prospective buyers that a flood hazard exists.

BUILDING FINANCING

24. Very little building is carried on without financing. Therefore, lending institutions, both Federal and private, are in a position to exercise some control over floodplain development by denying mortgage guarantees and funds to subdivision and private builders.

FLOOD INSURANCE

25. Flood insurance, if established on a sound and equitable basis, could provide still another supplement to many programs for reducing flood damage. However, insurance rates should realistically reflect the flood risk to discourage improper development of floodplains. A recently enacted National Flood Insurance Bill establishes a program of Federal assistance for flood insurance to be related to a unified national program for floodplain management. The program:

a. Provides for the formation of insurance company pools under the supervision of the Secretary of Housing and Urban Development.

b. Provides Federal premium subsidies and reinsurance coverage.

c. Provides that the property owner will bear part of the cost in the form of a premium.

d. Authorizes an alternative program under which private companies would act as fiscal agents for the United States Government in the event a program of private industry participation cannot be carried out.

e. Sets initial insurance limits for residential properties with provisions for gradual extension to most other forms of businesses, governmental operations, and other floodplain occupants.

f. Terminates eligibility for sale of flood insurance after 31 December 1971, unless permanent land-use regulations with effective enforcement provisions have been adopted, and at any time for property declared to be in violation of State or local land development ordinances.

g. Prohibits the granting of Federal disaster assistance with respect to property which is covered by flood insurance under the act.

h. Authorizes the Secretary of Housing and Urban Development to identify within 5 years all floodplain areas and within 15 years to establish flood-risk zones and make estimates of flood-caused losses in these zones.

The most probable future role for flood insurance is that it will provide a useful means of accomplishing other programs which will reduce the risk to a point where insurance is economically feasible. Flood insurance is not a complete solution to flood problems but is a possible means of providing the difference between partial flood protection and complete coverage against loss for structures already within the floodplain. Flood insurance has been available in Chaska since March 1971. A total of 72 residential properties were protected by insurance as of April 1973.

BRIDGES

26. Community expansion brings about the desire for more stream crossings. From a construction standpoint, perhaps the most economical method of providing crossings consists of roadways on earth embankments, with a small bridge or culvert to pass streamflows. However, this is often the least desirable from a flood damage point of view. If the structure is kept at a low elevation, it is frequently flooded and fails to serve its intended purpose. If the roadway is kept high, above the floodplain, it will act as a dam and increase flood stages upstream unless the waterway opening is adequate. Therefore, all future stream crossings in the East and Chaska Creek watershed should be designed to provide adequate waterway openings and bridge clearances and roadway heights above flood flows.

PERMANENT EVACUATION AS AN ALTERNATIVE
TO THE PROPOSED STRUCTURAL IMPROVEMENTS

27. As an alternative to structural means of regulating or containing flood flows, permanent evacuation of the Chaska floodplain and permanent conversion of land use were initially considered. This would involve the acquisition of some 390 acres of land by purchase, evacuation of about one-half of Chaska's present population, the relocation of about 540 homes and 40 commercial establishments, and the conversion of all valley lands within the city limits to less flood-damage-prone use. Preliminary estimates indicate that economic costs for the relocation would approximate $22 million. However, the additional economic costs associated with the foregone urban use of valley land were not evaluated. Because of its economic infeasibility and because other alternatives were found to be less costly and far more practicable and acceptable by local interests, the permanent evacuation plan was not considered further. Table E-1 provides a summary of the economic analysis of floodplain evacuation.

Table E-1 - Summary of evacuation costs and benefits

Total first cost	Average annual costs	Average annual damages	Average annual benefits	Benefit-cost ratio
$21,600,000	$1,223,000 (1)	$806,000	$728,000	0.6

(1) Average annual costs and benefits based on a 5 5/8-percent interest rate and an amortization period of 100 years.

FLOODPLAIN REGULATION AS AN ALTERNATIVE
TO THE PROPOSED STRUCTURAL IMPROVEMENTS

28. The city of Chaska in cooperation with the State of Minnesota has implemented a floodplain regulation program along the Minnesota River within the city. The East and Chaska Creek floodplains are not currently regulated because until this report the required engineering data had not been produced. Within the developed area of Chaska the pattern of development is well established and would be difficult to change. Thus floodplain regulation as an alternative at Chaska would most likely be limited to building codes requiring flood proofing for important and costly future facilities, eliminating basements of proposed new residences, elevating first-floor levels of proposed new structures where practicable above the intermediate regional flood levels, and the gradual conversion of land use and the gradual elimination of nonconforming uses within the floodway.

29. Land outside the floodplain in Chaska is generally well suited for development and accessible to existing highway routes, but the economic costs associated with increased development costs for utilities and streets and locational costs resulting from a

changed development pattern would be substantial. Table C-11, appendix C, presents an estimate of future flood damage reduction benefits from regulation of floodplain land use and development within the intermediate regional floodplain at Chaska. The analysis assumes that the future increase of damages to new growth would be negligible due to strict regulation of the floodplain as provided for by State law. The high residual damages with floodplain regulation lead to the conclusion that floodplain regulation alone would not constitute the optimum flood reduction plan for Chaska; i.e., the economic costs of corrective measures plus the costs of residual damages would not be minimized under this alternative. Thus, floodplain regulation has been evaluated further as a supplement to rather than a substitute for other flood damage reduction measures.

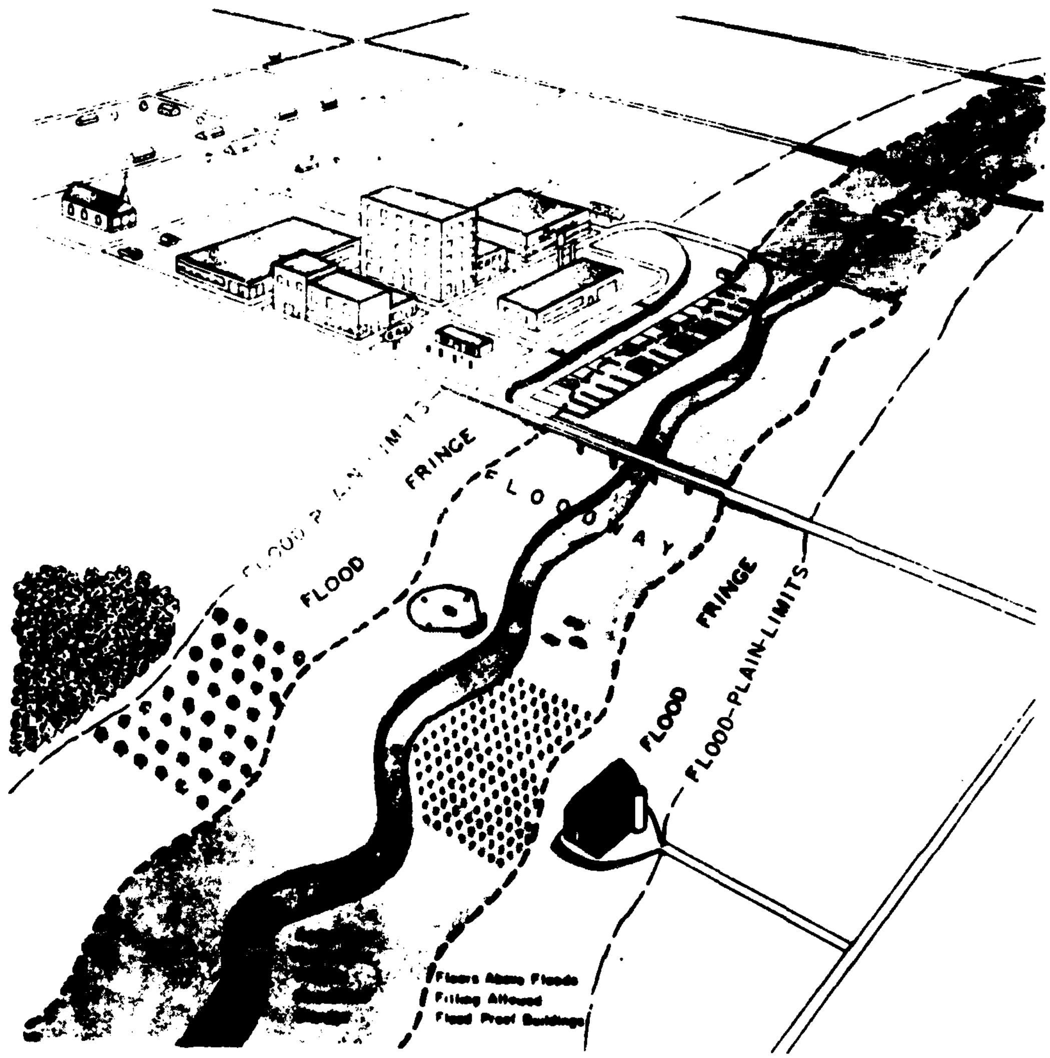
FLOODPLAIN REGULATION AS A SUPPLEMENT TO THE PROPOSED STRUCTURAL IMPROVEMENTS

30. Comprehensive planning for the city of Chaska must recognize the flood hazard which will exist until the proposed flood control measures are in place. Floodplain regulation for the Minnesota River floodplain should be continued and the East and Chaska Creek floodplains should be managed, allowing only wisely planned developments in recognition of the interim flood threat. The water surface profiles (plates E-4 and E-5) can be used by Chaska city officials as an approximate guide for planning developments for the interim period until the proposed channel diversion on Chaska Creek and the proposed flood bypass channel on East Creek can be constructed. It is recommended that during the interim period all developments be constructed in accordance with the provisions of the State Floodplain Management Act.

31. Although the proposed structural improvements would relieve much of Chaska from the need for floodplain regulation, zoning in accordance with State law for the residual floodplain would be required and is recommended as an integral part of the proposed plan. These regulations would insure conforming uses for the floodplain and the maintenance of the natural flood-carrying capacity of East and Chaska Creeks. The residual floodplain areas to be regulated (see plate 3) include all the areas on the outside of the levee along the Minnesota River, the areas upstream from the proposed bypass channel and proposed diversion channel on Chaska and East Creeks, respectively, the proposed ponding area adjacent to Courthouse Lake, and an area on East Creek near U.S. Highway 212. Such regulations would insure wise use of the floodplain zone and complement the open space river corridor plan proposed by the city of Chaska.

TECHNICAL ASSISTANCE AVAILABLE

32. Effective floodplain development plans require careful evaluation of the flooding potential and the determination of the effects upon flood flows of future floodplain use. These engineering determinations require technical experience and information which most communities do not have. In response to this need, the State of Minnesota, the U.S. Geological Survey, and the Corps of Engineers have programs to assist communities in evaluating the flood potential and relating it to floodplain management practices. The Corps of Engineers Flood Plain Management Services are available, to the extent funds are provided, to provide technical assistance to local governments in interpreting and evaluating basic flood data to assist them in making decisions for wise use of floodplain lands.



INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA

FLOOD PLAIN SCHEMATIC

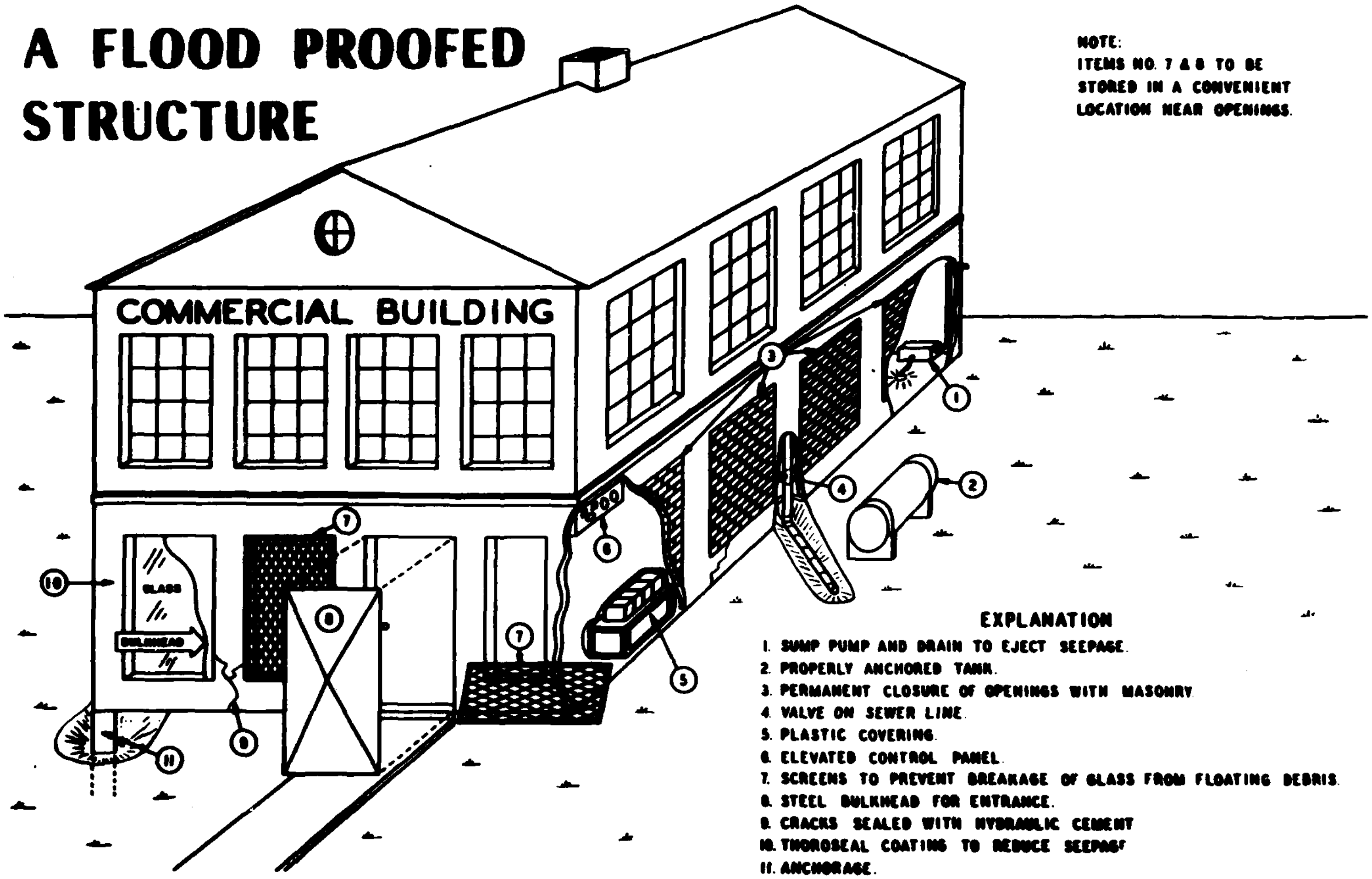
ST. PAUL, MINN. DISTRICT

FILE NO. **M34-CH-R-7/25**

PLATE E-1

A FLOOD PROOFED STRUCTURE

NOTE:
ITEMS NO. 7 & 8 TO BE STORED IN A CONVENIENT LOCATION NEAR OPENINGS.



EXPLANATION

1. SUMP PUMP AND DRAIN TO EJECT SEEPAGE.
2. PROPERLY ANCHORED TANK.
3. PERMANENT CLOSURE OF OPENINGS WITH MASONRY.
4. VALVE ON SEWER LINE.
5. PLASTIC COVERING.
6. ELEVATED CONTROL PANEL.
7. SCREENS TO PREVENT BREAKAGE OF GLASS FROM FLOATING DEBRIS.
8. STEEL BULKHEAD FOR ENTRANCE.
9. CRACKS SEALED WITH HYDRAULIC CEMENT
10. THOROSEAL COATING TO REDUCE SEEPAGE
11. ANCHORAGE.

FILE NO. M34-CH-R-7/31

Plate E-2

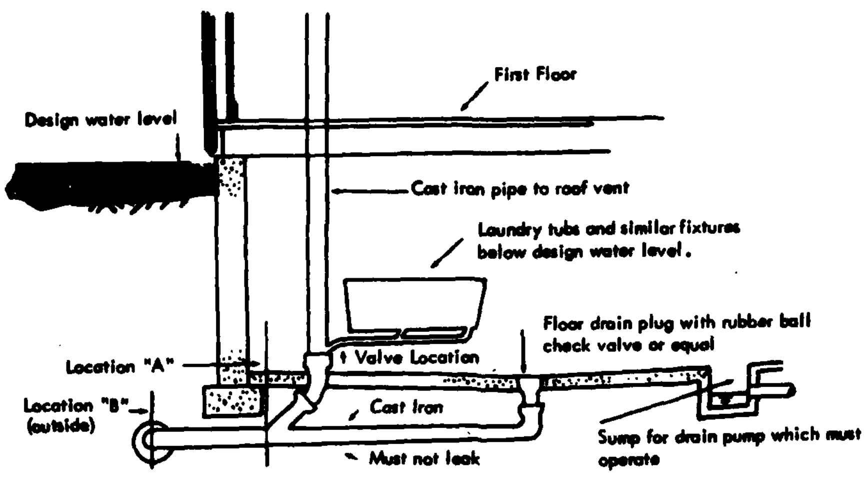


Figure E-1 - Alternative locations for cutoff valves on sewer lines.

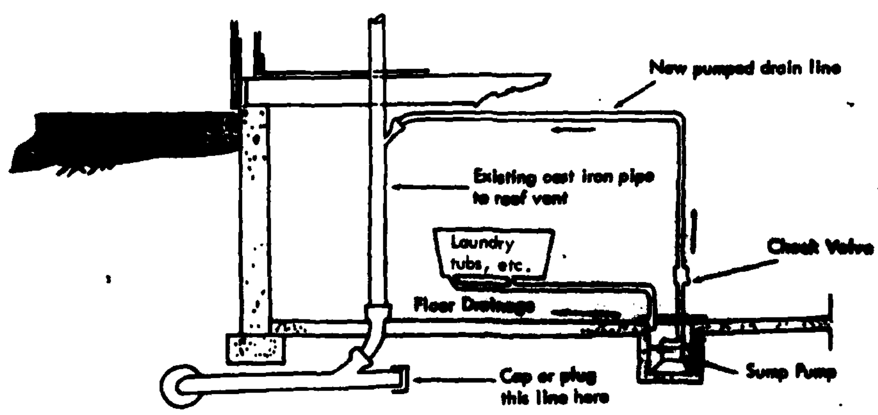
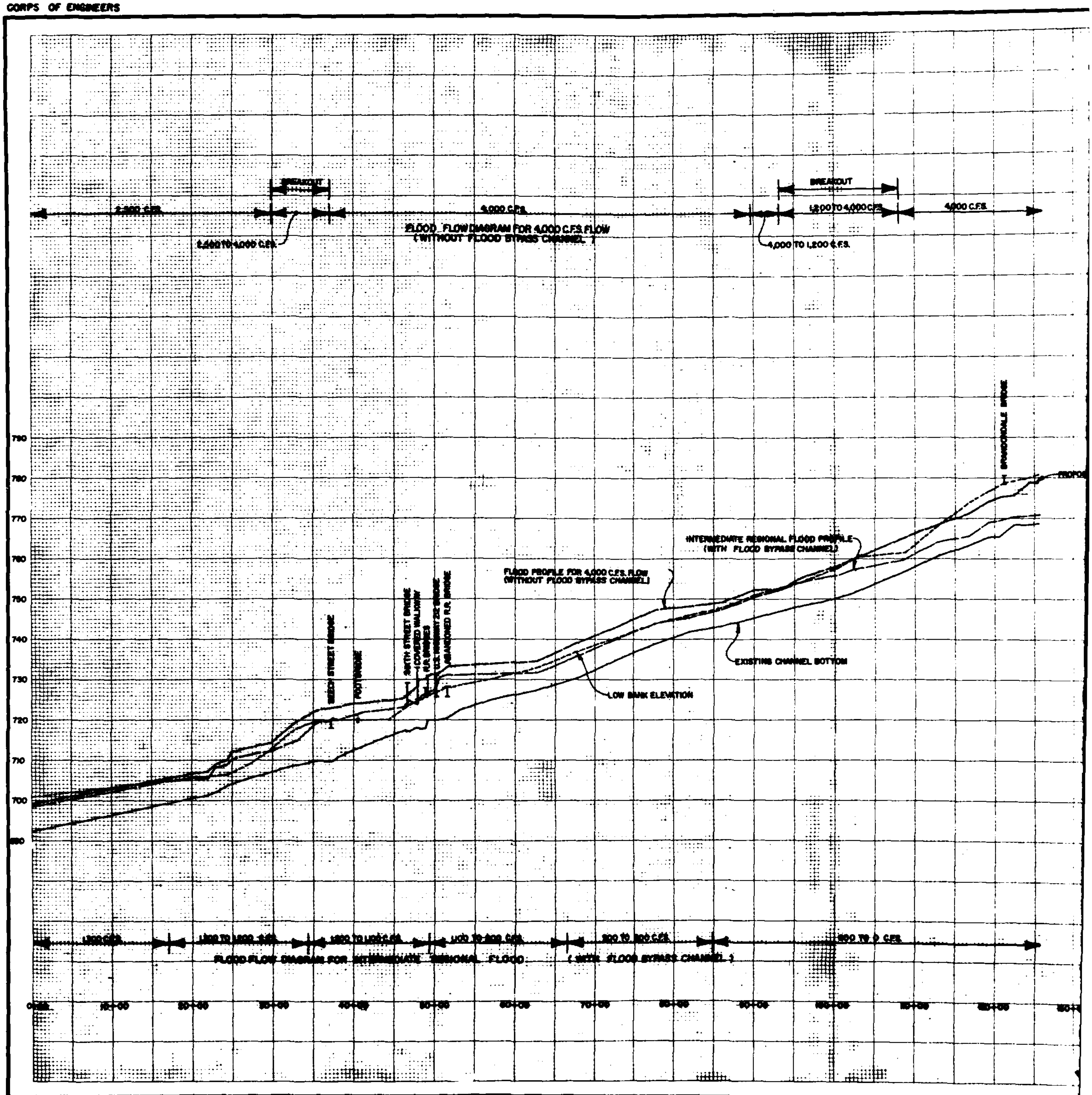


Figure E-2 - Elimination of gravity flow basement drains.

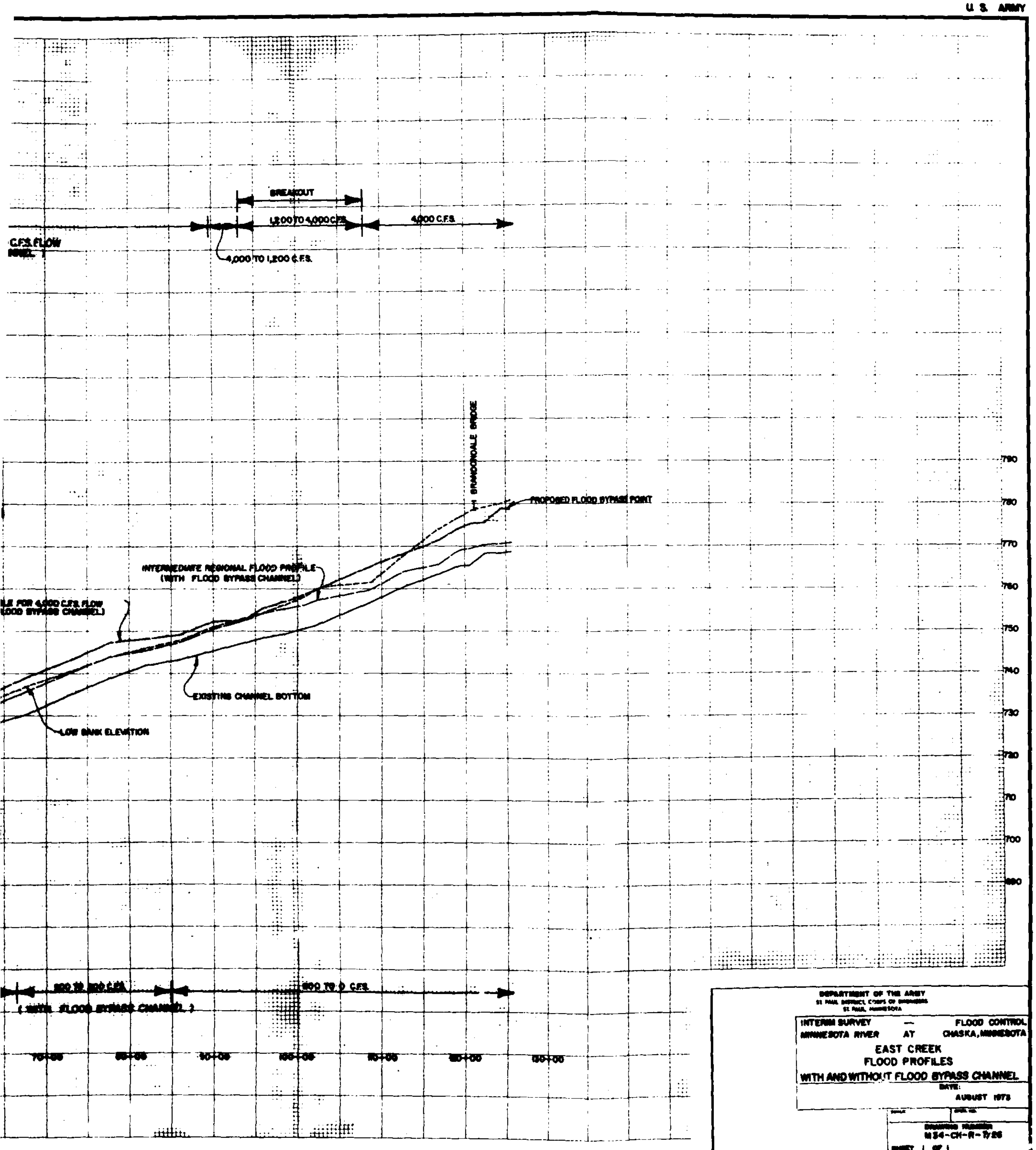
Methods for controlling sewer backup

FILE NO.
M34-CH-R-7/32 Plate E-3

CORPS OF ENGINEERS



U. S. ARMY



DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

INTERIM SURVEY — FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA

EAST CREEK
FLOOD PROFILES
WITH AND WITHOUT FLOOD BYPASS CHANNEL

DATE:
AUGUST 1973

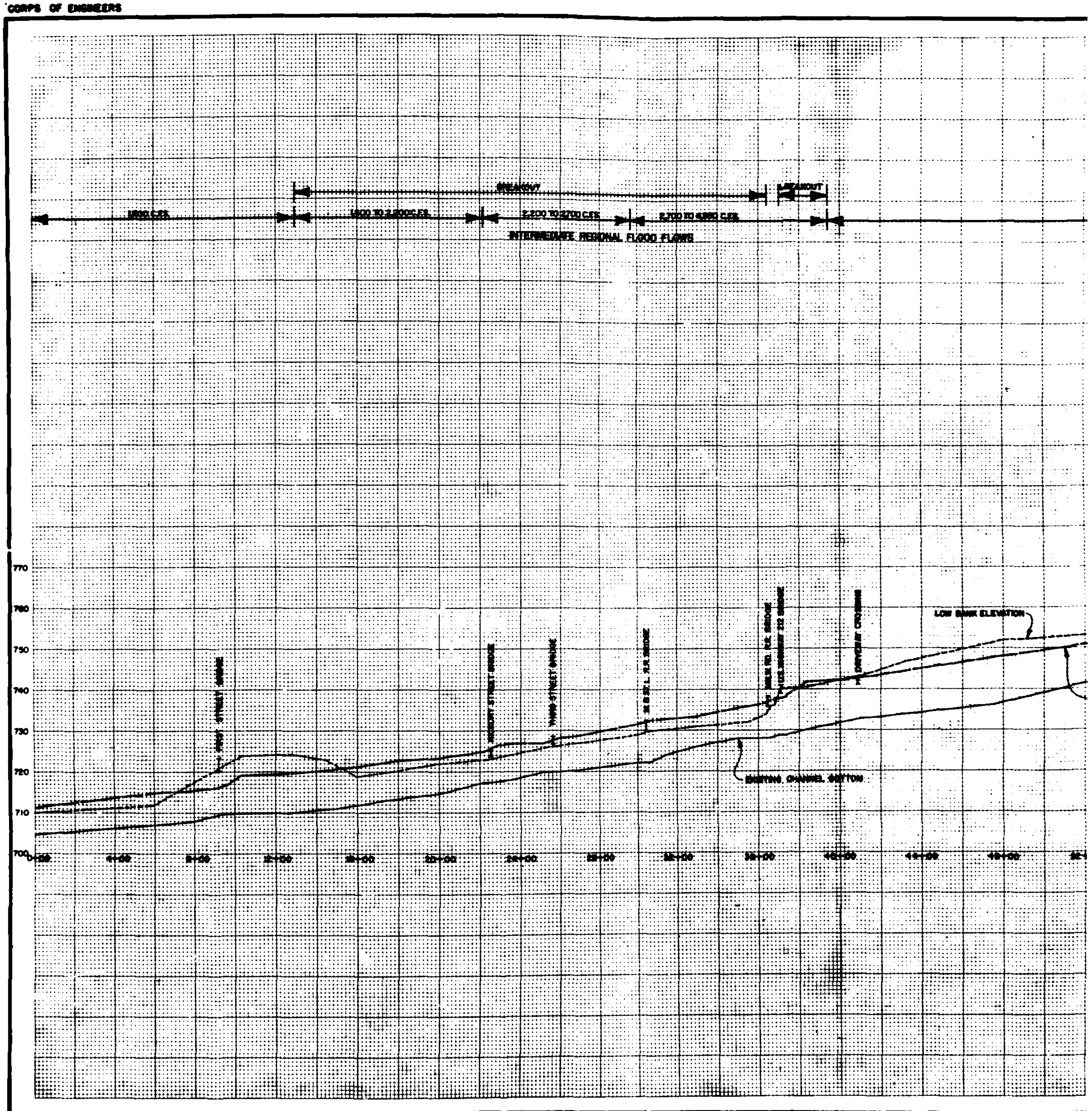
DRAWING NUMBER
M34-CH-R-7/26

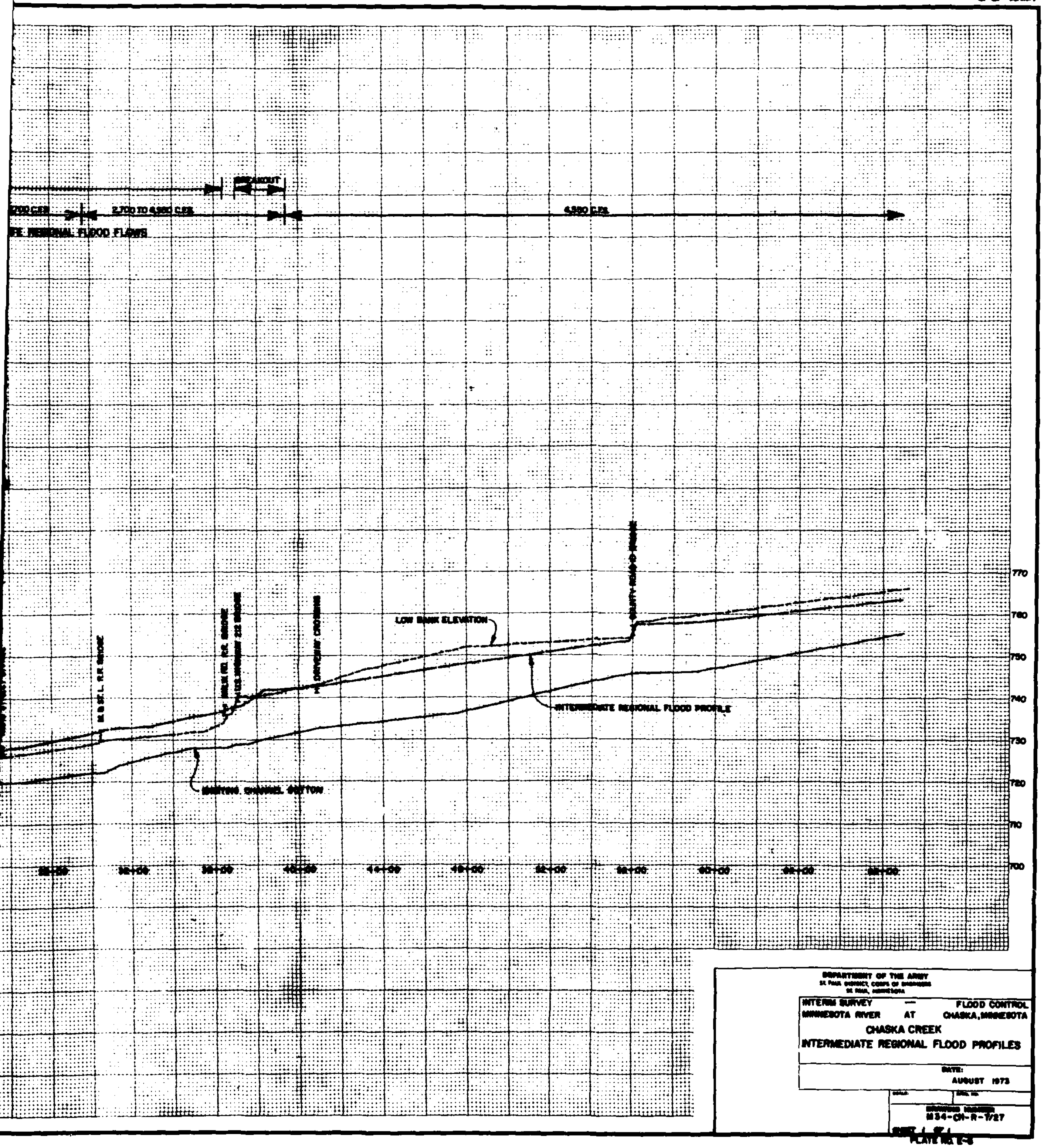
SHEET 1 OF 1

PLATE NO E-4

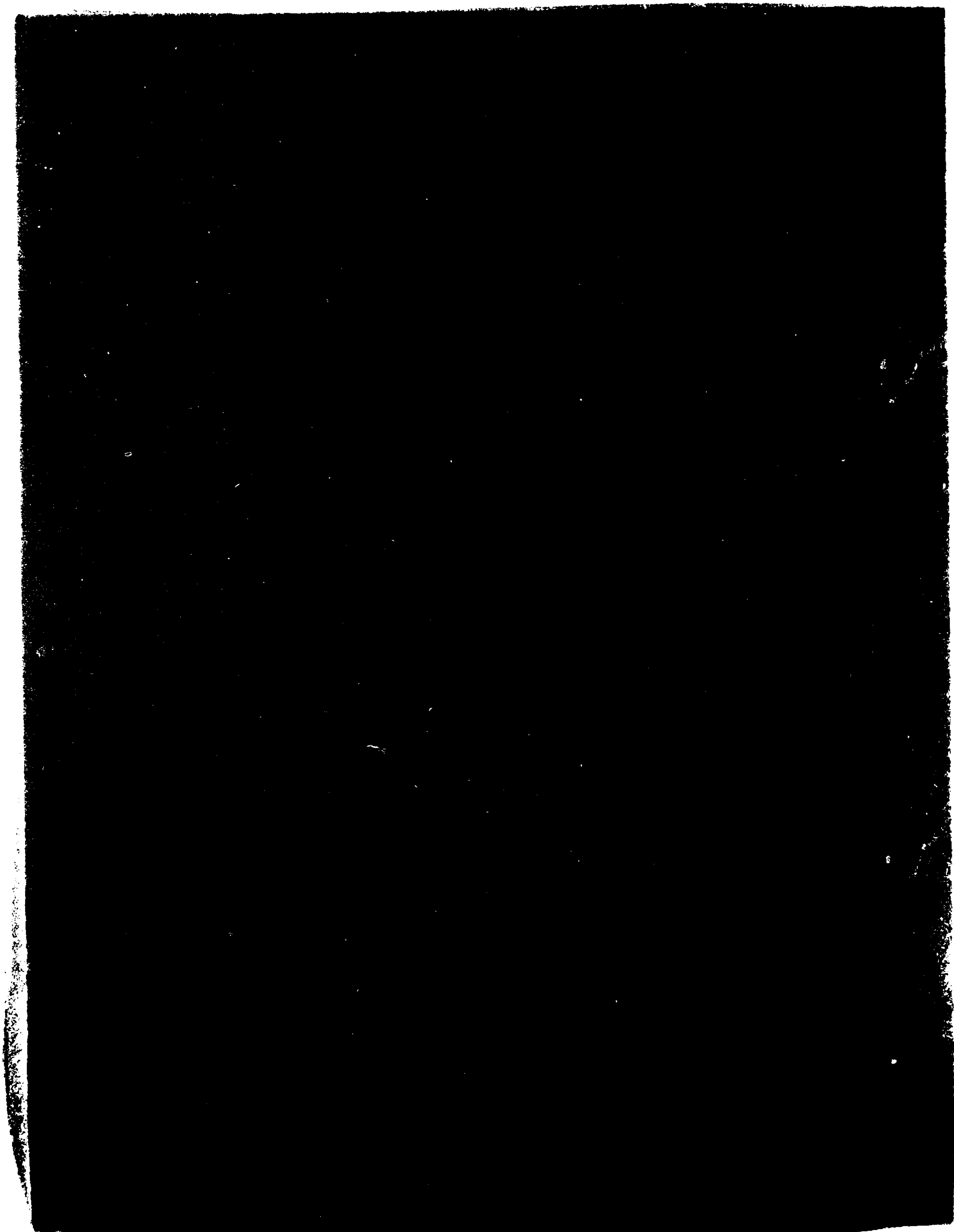
2

CORPS OF ENGINEERS




BREAKOUT
2,700 TO 4,550 C.F.S.
4,550 C.F.S.
LOW BANK ELEVATION
INTERMEDIATE REGIONAL FLOOD PROFILE
EXISTING CHANNEL BOTTOM
HIGHWAY 212 BRIDGE
PRIVATE DRIVEWAY CROSSING
770
760
750
740
730
720
710
700
DEPARTMENT OF THE ARMY
INTERIM SURVEY — FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
CHASKA CREEK
INTERMEDIATE REGIONAL FLOOD PROFILES
DATE:
AUGUST 1973
M34-CH-R-7/27
PLATE NO. E-5

2



APPENDIX F

ENVIRONMENTAL AND AESTHETIC CONSIDERATIONS

INTRODUCTION

1. The existing environmental setting is described and evaluated in this appendix. For technical data on climate, geology, soil, or economics refer to the appropriate appendixes in the report. The environmental impacts of the selected plan as well as the alternatives which were considered are examined in detail. Although this analysis is intended to account primarily for environmental factors, certain aspects of the social and economic setting are also considered in order to maintain unity of the appendix and to retain continuity with the draft Environmental Impact Statement.

LAND USE AND CONSERVATION NEEDS

2. Over 90 percent of the total land area in Carver County is in farms. This figure has been representative of the situation in the Chaska and East Creek watersheds until recent years. Development of the planned community of Jonathan, which is part of Chaska, is accelerating the urbanization of East Creek watershed and part of Chaska Creek watershed. Of the total 15,860 acres in the composite watershed, approximately two-thirds or roughly 10,000 acres is scheduled for eventual development as part of Jonathan. It is estimated at the present time that 300 to 400 of the 10,000 acres has been converted to cultural development such as buildings and roads. This leaves approximately 15,500 acres in farmland, wooded areas, and marshes and 400 acres in cultural developments above the bluffs of the Minnesota River valley.

3. Farm size in the county, in keeping with well-established, long-term national trends, is increasing. Present average size per farm is 143 acres as compared to 127 acres in 1959. Corn is the most important crop and alfalfa is second. Most of the farms have dairy or beef cattle.

4. The Minnesota Soil and Water Conservation Needs Inventory of 1971 indicates a need for the following practices within Carver County: drainage, strip cropping, terracing, contour plowing, sod rotation, annual cover, permanent cover, and pasture improvement. Representatives of the Soil Conservation Service, U.S. Department of Agriculture, are working actively with farmers and developers in the area to promote improved land use.

5. The U.S. Department of Agriculture, Soil Conservation Service made a field examination(1) of the possibilities of providing retarding structures in the upper reaches of Chaska and East Creeks in 1967. Five potential sites were examined; the findings indicated that a watershed project of upstream reservoirs could be developed but the economic feasibility would be questionable.

6. At the time of the Field Examination Report, specific needs for the composite watershed were identified as follows:

a. Protection of 1,500 acres from sediment and flooding.

b. Protection of 110 acres from erosion.

c. Drainage of 2,300 acres (60 percent of which was noncropland).

EXISTING WATER RESOURCE PROJECTS

7. No Federal project for flood control has been constructed at Chaska. The existing Corps of Engineers Lac qui Parle Lake for flood control and water conservation near the head of the Minnesota River is too far upstream to effect any significant reduction in flood stages at Chaska. A levee built by the city following the severe flood in 1952 provided protection against a 20-year frequency flood with 3 feet of freeboard. This levee with crest at elevation 720.0 was overtopped in the spring of 1965 by a flood which exceeded the stage of the 1952 flood by about 5 feet. Following the 1965 flood the levee was restored by the Corps of Engineers under the emergency operation authority of Public Law 99 and was subsequently raised about 4 feet by the city. The levee was again raised, about 2 feet, prior to the 1969 flood. This raise was accomplished with assistance of the Corps of Engineers, again through Public Law 99. The levee is not tied into high ground at either end.

ECOSYSTEMS IN THE CHASKA AND EAST CREEK WATERSHEDS

8. GENERAL

Wooded and marshy areas for East and Chaska Creek watersheds above the bluffs of the Minnesota River valley are given in table F-1. The areas were planimetered from U.S. Geologic Survey quadrangles dated 1958.

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(1) Field Examination Report, Chaska and Hazeltine-Bavaria Watershed, Carver County, Minnesota, 1967.

Table F-1 - Wooded and marshy areas in the East and Chaska Creek watersheds

Description	East Creek drainage Area (acres)	East Creek drainage Percent of basin area	Chaska Creek drainage Area (acres)	Chaska Creek drainage Percent of basin area
Woodland				
Upland woodland	455	6.8	740	8.0
Lowland and ravine woodland	405	6.0	400	4.3
Total woodland	860	12.8	1,140	12.3
Total marshland	480	7.2	1,240	13.5
Lakes	309	4.6	88	0.9
Total area of drainage above the valley bluffs	6,650	24.6	9,210	26.7

9. The original vegetation in the vicinity of Chaska was a Maple-Basswood subdivision of the Temperate, North American Deciduous Forest. Most of the upland areas have been cleared for agricultural purposes and only about 12 percent of the East and Chaska Creek watersheds are currently wooded. Other vegetational associations which are identifiable from the area include oak woodland, prairie grassland, and wetlands.

10. THE MAPLE-BASSWOOD FOREST

The maple-basswood forest was part of an area termed the "Big Woods" by early settlers.(1) The species comprising this forest type are generally not resistant to fire although they are capable of developing under a forest canopy and perpetuating themselves; i.e., are components of the "climax" vegetation of the area, the end product of succession. Before man's fire control became effective, prairie fires swept into this region from the west and southwest. These fires maintained some of the area in prairie, oak savanna, or oak forest. The Minnesota River, and to some extent the frequent smaller wetlands on the Chaska and East Creek watersheds, acted as natural firebreaks, however, and allowed development of the fire-sensitive climax vegetation on much of the watershed area.

(1) Daubenmire, R. F., The "Big Woods" of Minnesota: Its Structure, and Relation to Climate, Fire, and Soils, Ecological Monographs 6:235-268, 1936.

11. The dominant species in a maple-basswood forest is the sugar maple. This species is normally present in all size classes. Sugar maple has the ability to persist for years in a slow-growing state in the deep shade under the forest canopy. When members of the overstory die, these suppressed sugar maples respond and fill gaps in the canopy. Because of this, sugar maple tends to increase in importance with time in maple-basswood forests.

12. Codominant species vary as to locale but typically include the basswood and American elm. Other tree species normally present include the northern red oak and bitternut hickory. These species usually have an ecological niche similar to that of sugar maple but with a lesser ability to persist in a suppressed stage and to respond to openings in the canopy. Ironwood may also be present as a small tree under the canopy.

13. The shrub layer is rather sparse in the maple-basswood forest, perhaps due to the influence of the dense overstory.

14. The herb layer in this forest is usually well-developed, although low in stature. Species present are those able to survive in deep shade and may typically include such species as hepatica, catbriar, rattlesnake fern, maidenhair fern, and the putty-root orchid. Wood nettles are abundant in some maple-basswood forests.

15. Normally a considerable variety of small animals is present. The invertebrate animals in the soil are usually present in far greater variety and number than in an oak forest. Reptiles are not common in the maple-basswood forest but rather tend to be found in earlier successional stages, especially near wetlands. The same generally holds true for amphibians although some, such as the common toad, are found. Temporary pools in the forest may harbor a considerable amphibian fauna during the spring breeding season.

16. The mammalian fauna is modest in this forest. The larger species such as white-tailed deer and red fox are normally present, although this forest is mainly important to them for cover while food is sought elsewhere. The smaller mammals may include mice and squirrels, although large populations of these species are usually associated with other kinds of ecosystems.

17. The avian fauna is diverse but typically includes few of the larger species except for the predatory birds which may nest here and feed elsewhere. A considerable variety of small birds such as the warblers, however, feed upon the diverse insect fauna.

18. THE OAK FOREST

The oak forest may not have been originally very extensive on the Chaska and East Creek watersheds. It probably occurred under two conditions: (1) on dry slopes and hilltops and (2) on certain fire-prone upland sites. The canopy in an oak forest is composed mainly of pin and white oaks and, in this area, tends to be incomplete in recent years due to oak wilt disease which kills a significant portion of the pin oaks in some areas. Other species include box elder, black cherry, quaking aspen, and paper birch. These four species are not as large and long-lived as the oaks, however, and typically occur in disturbed areas or, in the case of quaking aspen, where forests are advancing into grassland. Basswood is also present, at least on the more moist sites.

19. The oak forest typically has a more developed understory than the maple-basswood forest, probably because the canopy is more sparse and interrupted. Saplings of the overstory trees may be common if the canopy is sufficiently discontinuous. Species typical of other forests may also occur, such as American elm and green ash. Shrubs also exhibit profuse growth and include species such as the dogwoods. The general aspect is of a forest with all size classes of trees, with a considerable brushy undergrowth in contrast to the aspect of the maple-basswood forest of a tall forest with little undergrowth.

20. Herbaceous growth is also profuse in an oak forest, at least where the low woody growth is not too intense. The herbs exhibit quite a variety of growth forms and statures. The herb layer presents an unkempt appearance in contrast to the more even range of sizes in the maple-basswood forest. Few species of herbs can be described as typical of an oak forest, but rather the herb flora is an assemblage of species from all stages of upland succession. A number of pioneering species such as various asters are usually found, and grasses may be important.

21. The soil invertebrates in an oak forest include the same groups as in the maple-basswood forest, although the numbers or organisms per unit area are usually lower. The soil layers are normally thinner, and the organic layers are less well-developed and apparently less rich and productive.

22. The mammalian fauna typically includes more of the larger forms. Both the grey and fox squirrels are present although the fox squirrel tends to be associated with, and forage in, croplands. White-tailed deer normally find a brushy oak forest to their liking, both for cover and food such as browse and acorns.

23. The avian fauna in an oak forest is diverse and includes many species found in a maple-basswood forest. More of the low-level and early successional stage species are found, probably due to the greater development and variety of low woody vegetation. Some game birds such as the ruffed grouse may also be present.

24. The oak forest ecosystem on the Chaska and East Creek watersheds has probably not been as adversely affected by man's activities as has the maple-basswood forest. The steep slopes and hilltops where the oak forest originally was found are not heavily used for agriculture or habitation. On the less severe sites where it may have been maintained by disturbance, the oak forest probably has been cleared although the soils are not of high quality for agriculture. On parts of the watershed where the maple-basswood forest was disturbed - and those forests have been extensively cleared for agriculture - the oak forest may have increased in areal extent because of its tendency to advance into disturbed areas.

25. THE PRAIRIE

Apparently some natural prairie existed on the Chaska and East Creek watersheds. The prairie was maintained by fire as the climate in the region will allow the development of woody vegetation in the absence of disturbance. Because of the plethora of natural firebreaks on these watersheds, the prairie was probably of limited extent. None of the natural prairie has been identified on the Chaska and East Creek watersheds.

26. THE WETLANDS

As indicated in table F-1, about 1,700 acres of marsh is found in the Chaska and East Creek watersheds. These marshes, situated in an area of considerable agricultural activity and growing urbanization, have been reduced in diversity and areal extent by man. Wetland drainage continues in agricultural areas. However, a theme of ecological balance is incorporated into the Jonathan development on the East Creek watershed. This is expected to preserve some wetlands in the upper watershed. As a growing philosophy especially in local urban development is to preserve "green belts", social and political pressure for wetland preservation can be expected to increase in the future.

27. Commercially important furbearing animals in this region, the mink and muskrat are associated with wetlands. Estimates of mink harvest in the area are one animal per 1 to 4 square miles. Like the muskrat harvest, the mink harvest reflects fur prices and not necessarily population levels.

28. Approximately 200 additional acres of wetland are confined to a bench east of Chaska and between Carver County Highway 17 and Bluff Creek on the west and east and Highway 212 and the valley bluffs on the south and north. The Minneapolis and St. Louis Railroad bisects the wetland from west to east. The portion north of the railroad is a marsh with cattail, bulrush, and smartweed against the scenic background of the valley bluffs. South of the railroad, the wetland is a wet meadow instead of a typical marsh, which may reflect the impact of the railroad embankment in shutting off the source of water. This wetland may be altered in that (1) the Minnesota Department of Highways would, under one alternate plan, relocate Trunk Highway 41 through the marsh about a half-mile east of the existing County Highway 17; and (2) real estate developers have indicated an interest in establishing industry in this area which is currently zoned for industrial land use and development.

29. THE FLOODPLAIN FORESTS

Although several stages of development of floodplain forests occur, only more mature stages appear to be located in the vicinity of the alternate plans under study. Although members of this ecosystem advance up the valley slopes and species typical of the uplands invade this ecosystem, the floodplain forest is generally restricted to the relatively flat valley floor and occurs on a substratum of silt with high mineral content and considerable organic matter. Thus, the sites are rich, have been periodically flooded, and are rather moist. The floodplain forest is highly productive and the vegetation grows rapidly. The basic productivity is maintained, at least in part, by the fertilizing effects of periodic floods.

30. The tree stratum is composed of cottonwood, American elm, silver maple, green ash, box elder, and hackberry. Where an understory is present, such as in places where the canopy has been broken, it consists almost entirely of trees of the same species as the canopy. Although these species are characteristic of the floodplain, none of them is restricted to floodplains.

31. The herb flora in floodplain forest areas adjacent to the existing emergency levee and along portions of East Creek is not well developed because of dense tree and shrub layers. Such species as wild cucumber and common and wood nettles, which are generally indicative of floodplain conditions, are present.

32. Characteristic wildlife of floodplain forests in this area includes deer, fox, rabbit, red and grey squirrel, waterfowl, pheasant, a variety of predatory and songbirds, and many of the smaller, less conspicuous invertebrate animals such as earthworms and insects. Many of these, such as the deer and migratory birds, use the floodplain forest seasonally. In the case of the present study, the

floodplain areas of immediate concern include about 5 acres in a narrow strip along East Creek and the narrow zone along the outside of the existing emergency levee which consists of about 10 acres of interspersed floodplain forest and wetland.

33. BIOLOGICAL SYSTEMS OF OPEN WATERS

Chaska Creek, in the 3/4 to 1 mile below the bluffs of the Minnesota River valley, passes through the urban area of Chaska. This section of the creek has been lined with riprap and concrete, and much of the streambank vegetation has been removed. Shade is generally lacking in this lower portion of the creek and very few natural characteristics of vegetation or wildlife are apparent.

34. East Creek passes through a wooded area between the Brandondale development of the Minnesota River bluff and the point where it enters the more densely urban area. The streambank vegetation provides shading of the stream. A moderate biological system is present, including green herons which feed on small fish in the stream. East Creek has been diverted at least twice during the past. One former path was along existing Bluff Creek to the east. The urbanized portion of East Creek is presently in a condition similar to the urban portion of Chaska Creek.

35. Courthouse Lake is in the floodplain just outside the existing levee. It is managed as a "put and take" fishery by the Minnesota Department of Natural Resources which stocks brown and rainbow trout in it. During past floods on the Minnesota River, rough fish and debris have been washed into the lake, necessitating cleanup and rough fish control. Rough fish control is normal in "put and take" trout lakes; however, local fishery managers have indicated that protection of Courthouse Lake would result in a slight net benefit.

36. The Minnesota River in the vicinity of Chaska has a bottom of mostly shifting sand with some silt and few areas of gravel and boulders. High temperatures range above 80° F during the summer. The Minnesota River supports a varied fishery including northern pike, walleye, and white bass. Because of the shifting and unstable bottom types in the vicinity of Chaska, fishery values are presently low in this reach of the river.

WATER QUALITY

37. Water quality has been monitored since 1961 at a Minnesota Pollution Control Agency sampling station located on the Minnesota River near the U.S. Highway 169 bridge near Shakopee, Minn. Selected parameters of water quality are shown in table F-2 for the period of record.

Table F-2 - Selected parameters of water quality (since 1961)

Parameter	Minimum	Maximum	Mean
Dissolved oxygen, mg/1[1]	1.50	15	8.39
5-day BOD, mg/1	0.50	40	6.35
Temperature, °F	31	81	55
pH	7.2	8.7	7.8

(1) Milligrams per liter.

38. The figures for minimum dissolved oxygen and maximum BOD from table F-2 indicate periodic oxygen depletion. This occurs because point sources of treated waste water and runoff of agricultural pollutants exceed the assimilative capacity of the Minnesota River.

39. The reach of the Minnesota River adjacent to Chaska is presently covered by regulation WPC 5 of Minnesota Administrative Rules, Regulations, Classifications, and Water Standards, as enforced by the Minnesota Pollution Control Agency. The standards have a minimum allowable oxygen level of 3 mg/1 and a maximum 5-day BOD (biochemical oxygen demand) limit of 25 mg/1 for effluents. Water quality data are not available for East and Chaska Creeks. No water quality problems have been recognized from either creek; however, the extensive agricultural activity in the composite watershed indicates that these small streams receive considerable nutrients and possibly some pesticides and herbicides.

40. The Minnesota Pollution Control Agency has made two specific studies[1] on the feasibility of raising dissolved oxygen standards for the lower Minnesota River. It was concluded that under the summer study conditions, 5 mg/1 of dissolved oxygen could be maintained in the river with existing standards of 25 mg/1 BOD through 1985. However, it would not be possible to maintain a minimum dissolved oxygen level of 5 mg/1 during winter when the river is ice-covered.

AIR QUALITY

41. Chaska does not have any noticeable air quality problems. Sulfation and dustfall have been monitored by the Minnesota Pollution Control Agency and the following data are taken from annual summaries furnished by the Division of Air Quality, Technical Services Section (table F-3).

(1) Minnesota Pollution Control Agency, Division of Water Quality, Memorandum on Feasibility of Higher Dissolved Oxygen Standards for the Lower Minnesota River, 1971.

Table F-3 - Data on sulfation and dustfall in Chaska, Minn.

	Sulfation		Dustfall	
Year	Mean	Percent[2] greater than standard	Mean	Percent[2] greater than standard
1971[1]	0.3 mg $SO/_3$100 Cm^2/day	0	25 $T/Mi^2/Mo$	67
1970	0.1 mg $SO/_3$100 Cm^2/day	0	30 $T/Mi^2/Mo$	82
1969	0.1 mg $SO/_3$100 Cm^2/day	0	39 $T/Mi^2/Mo$	75

(1) January-March only.
(2) Percent of the time during which the parameter exceeded the applicable standard.

State Standards: Sulfation - mg $SO_3$100 Cm^2/day-0.25 maximum annual mean.
Dustfall - tons/Mi^2/month-15 tons including background in all areas except heavy industrial-zoned.
All mean = "Arithmetic"

42. The city has no industry which would tend to emit air pollutants; however, considerable dust becomes airborne on surrounding farmlands. Some mildly objectionable odors are occasionally emitted from a local pickle plant.

SOLID WASTE

43. Solid wastes generated in Chaska are collected by local trash haulers and disposed in the Louisville landfill in Scott County just west of Highways 41 and 169. Some solid waste including abandoned autos is occasionally disposed of in the Minnesota River floodplain.

SEWAGE TREATMENT

44. The sewage treatment plant at Chaska is owned and operated by the Metropolitan Sewer Board of the Twin Cities area. The plant provides secondary treatment and utilizes the contact stabilization process which is a modification of the activated sludge process when activated sludge solids are stabilized by bacterial action under aerobic conditions. The plant was designed for a population equivalent of 7,500 persons and a flow of 0.75 million gallons per day.

45. The effluents are discharged to the Minnesota River and the plant is situated just inside the existing flood control dike. Effluent conduits from the plant are not functional at river stages above 17 feet and, when this stage is exceeded, sewage effluents must be pumped over the dike with auxiliary equipment. The Minnesota Pollution Control Agency standards of 25 mg/1, maximum BOD, and 30 mg/1 maximum suspended solids apply to effluents of the Chaska sewage treatment plant.

46. The Chaska waste water treatment plant is loaded at approximately 75 percent of its design flow, on the average. Process efficiency has been varied with effluent BOD values ranging from 10 to 74 mg/l, and effluent suspended solids values varying from 23 to 127 mg/l during the 11 months prior to January 1972. Surveys of operation conducted in November and December 1971 indicated some areas where modifications in operational practices would result in improvement in process efficiencies. These practices were instituted in January 1972, and with the exception of one brief setback in February of that year, have been very successful. Long-range future plans (1985-2000) call for pumping waste water flows to a regional treatment plant situated at Blue Lake along the Minnesota River several miles east of Chaska.

HISTORY AND ARCHEOLOGY

47. Carver County, established 20 February 1855, was named for Captain Jonathan Carver, an English explorer and author. Chaska was the first village in the county. At the time of colonization, the area was occupied by Sioux Indians.

48. An inventory of historically or archeologically significant sites in the vicinity of Chaska was provided by the Minnesota State Historical Society and is tabulated below. None of these sites would be affected by the selected plan.

a. Mounds and earthworks. -

(1) Carver County. -

(a) W 1/2 of NW 1/4, sec 9, T 115 N, R 23 W. In the public square at Chaska. Three tumuli mounds. Surveyed August 28, 1892. (Winchell, N. H., The Aborigines of Minnesota, Minnesota Historical Society, St. Paul, 1911, pp 180-181.)

(b) SE 1/4 of SE 1/4, sec 9 and SW 1/4 of sec 10, T 115 N, R 23 W. A group of 69 mounds 100 feet above the river bottom. (Winchell, N. H., The Aborigines of Minnesota, Minnesota Historical Society, St. Paul, 1911, p 191.)

b. Historic sites. -

(1) Oliver Faribault Post at Chaska. - Located at the present site of Chaska. Further research needed to determine exact site. Faribault was operating a fur post and a large farm here in 1842. (W.P.A. Writers' Project, Box 218, Mss. MHS)

(2) *Thomas A. Holmes Post.* - Located at present site of Chaska. This post was established in 1851. (W.P.A. Writers' Project, Box 218)

(3) Mission of St. Francis Xavier. - Located on the west bank of the river at Chaska. The mission house was built by Father Augustin Ravoux in 1843. After 1 year the mission was closed and the chapel was ultimately dismantled and shipped to Wabasha. (Sister Mary A. Norton, Catholic Missionary Activities in the Northwest, 1818-1864, pp. 78-79.)

49. Mr. Edward Weinzierl, local historian with the Carver County Historical Museum at Waconia, was consulted as to possible locations of historic or archeologic sites near Chaska. He knew of no additional sites.

SELECTED PLAN OF IMPROVEMENT

50. The selected plan of improvement for Chaska consists of diverting 0.9 mile of Chaska Creek and bypassing flood flows on 1.2 miles of East Creek around the heavily developed areas of the city, combined with the upgrading and extension of the existing emergency levee and provision of adequate interior drainage facilities. A detailed description of the plan can be found in the main report.

ENVIRONMENTAL IMPACTS OF THE SELECTED PLAN

51. GENERAL

The environmental impacts are interpreted here to include certain aspects of the social and economic situation as well as aspects of the natural environment which pertain mostly to the natural sciences and are generally regarded as the main focus of the environmental quality planning objective. Development of the best possible plan for Chaska was based on the following:

a. The plan must preserve to the maximum possible extent the quality of the natural and human environment.

b. The plan must be socially acceptable.

c. The plan must enhance the economic welfare of the local people and add to their security and well-being.

d. The plan must enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency.

e. The plan must fit integrally into an overall plan for water and related land resource management and development for the Upper Mississippi River basin.

f. The plan must be technically feasible to implement.

52. The upgraded and extended levee, interior drainage provisions (including temporary ponding), and flood bypass channels which are proposed for Chaska would impact upon the environment from the economic, social, and biological viewpoints. Certain of the effects would be temporary, lasting only for the duration of construction activity. Other effects which are either caused directly by the proposed structures or related land-use changes would last as long as the structures remained in place. For purposes of this report, that period is taken as an assumed 100-year economic life, even though it is quite likely that the structures would be maintained as long as the need for the project exists.

53. IMPACTS UPON CLIMATE, GEOLOGY, SOILS, AND GROUNDWATER

The proposed plan of flood control for Chaska is not expected to impact significantly upon the climate, geology, and soils of the area. Some temporary airborne dust is possible during construction. This problem would be partially controlled by using water trucks for on-site sprinkling. Most of the material excavated from the flood bypass channels would be used in constructing the levee and in providing overburden areas for landscaping and planting. The remaining material would be placed in environmentally acceptable areas provided by the local sponsor. Since neither of the creeks serves as a major recharge source for the aquifers which supply city wells, the proposed diversions are not expected to affect the quality or quantity of appropriated groundwater.

54. IMPACTS UPON SURFACE WATERS AND AQUATIC BIOLOGICAL SYSTEMS

Significant downstream effects on the Minnesota River and its floodplain would not occur because the peak flows from East and Chaska Creeks do not produce sufficient water volumes to noticeably increase downstream stages of the Minnesota River. Any floodplain constriction resulting from the levee work at Chaska would be minor, and would not cause measurable alteration of upstream or downstream stages.

55. The proposed levee alignment would protect Courthouse Lake from flooding by the Minnesota River; however, the lake would be utilized as a ponding area during the rare event that flood stages occurred simultaneously on the Minnesota River and East Creek. The net impact on the lake would be slightly beneficial to local recreation and the lake fishery, because the introduction of large debris and rough fish from the Minnesota River causes greater fishery management problems than such smaller fish and the limited debris which might be introduced from East Creek watershed.

56. The proposed diversion of Chaska Creek would result in the loss of about 0.6 mile of existing urban stream channel which has generally been straightened and lined with concrete and riprap in the past. The diversion channel would eventually develop characteristics similar to

those of the existing, modified stream bed. The existing channel of Chaska Creek would continue to serve interior drainage as a part of the selected plan. Local interests, according to the provisions of the proposed plan, would be required to provide substitute means of interior drainage if it were ever decided to alter the existing channel.

57. The proposed flood bypass for East Creek would eliminate flood stages from the existing stream channel but low flows and the existing aquatic system, including the possible downstream or upstream movement of small fishes, would be maintained.

58. The flood bypass for East Creek and the channel diversion for Chaska Creek would be excavated under dry conditions; therefore, no sedimentation of either Chaska Creek or the Minnesota River would occur during most of the excavation work. At the time of the installation of the diversion and bypass structures, however, a small amount of sediments and any loose material remaining in the newly excavated channels could be carried downstream and into the Minnesota River.

59. The flood bypass for East Creek would pass adjacent to the west end of an approximately 230-acre marsh. The natural drainage outlet for this area is to the east via Bluff Creek; however, about 30 acres are topographically situated so as to possibly be drained into the bypass channel. A substantial portion of this 30 acres has been drained into Bluff Creek via ditches constructed by local interests. Accordingly, drainage of the 30-acre area, which is zoned for industrial development, is not taken as an impact of the proposed flood bypass channel.

60. The proposed Highway 41 relocation alignment (see transportation section of main report) would be immediately to the east of the flood bypass channel. The deep fills required for a highway embankment would block the natural drainage from the east of the highway unless culverts or other drainage improvements are installed.

61. IMPACTS ON TERRESTRIAL BIOLOGICAL SYSTEMS

The proposed levee modifications would require that about 10 acres of interspersed wetlands and bottomland woods be cleared to provide room for lengthening and widening the existing emergency levee system. The diversion route proposed for Chaska Creek would require that about 2½ acres of elm and box elder trees and saplings, as well as some 12 to 15 willow trees, be cleared. The narrow zone of shrub and woodland cover along East Creek would be affected with the elimination of flooding along the creek because riparian biological systems of this type are maintained, at least in part, by the fertilizing effects and moisture which occur during floods.

62. IMPACTS ON LAND USE

Future land use in the upper watersheds of both Chaska and East Creeks will gradually shift from agriculture to intense urban development either with or without the proposed plan, as discussed in paragraph 2.

Protection of the three floodplains from the intermediate regional flood would expedite future development of the floodplains of Chaska and East Creeks (approximately 150 acres presently undeveloped). Only about five undeveloped lots remain in the Minnesota River floodplain area of Chaska. Approximately two-thirds of the 150 acres, presently designated as future greenbelt and open space, would not be affected by the plan. The remaining one-third is presently zoned for commercial, industrial, and residential development. It is expected that this area would be developed either with or without the proposed plan.

63. IMPACTS UPON ECONOMY AND THE SOCIAL SETTING

The total first costs of the plan selected for Chaska would be $9.54 million of which $1.28 million would be non-Federal costs. Average annual benefits, based upon 100-year project life, would be $767,000, and the benefit to cost ratio is 1.3. Average annual flood damages would be reduced by 88 percent. Approximately 390 acres of urban developments, including about 540 homes and 47 businesses, would be protected from the intermediate regional flood. A few undeveloped properties along the East Creek bypass channel would be severed and about 13 residential relocations would be required for the entire project. The residences taken would include six semipermanent mobile home installations near the point of diversion of East Creek, three houses at the crossing of the East Creek diversion channel and Stoughton Avenue, and four homes near the levee along the Minnesota River. About 20 acres of commercial and industrial zoned land would be required for construction of the diversion and bypass channels.

64. An improved social setting would result from the residents' safety and lack of worry and anxiety during flood seasons. An additional benefit would be the elimination of community disruption during actual floods. Local property maintenance would improve with the implementation of flood protection, and the general appearance of presently flood-prone property would benefit.

65. The evacuation or relocation of about 13 residences would be required with implementation of the selected plan. Considering the present liberal policy of the Federal Government toward relocation assistance, no serious inconvenience or hardships would be imposed upon those required to relocate although this assumes that they are willing to move. Any person who would be required to relocate and did not desire to do so for any personal reason would be adversely affected. In this case, the adverse effect would be unavoidable because every effort has been made during the planning process to minimize all adverse effects, including relocation.

66. IMPACTS UPON SOLID WASTE DISPOSAL, SEWAGE TREATMENT, AND PUBLIC HEALTH

The selected plan would not affect solid waste disposal. The sewage mains from the Jonathan addition in Chaska, which are located in the valley of East Creek, could possibly be breached in the event of a damaging flood from this watershed. However, the proposed project would not affect this situation.

67. The potential for vector breeding, well contamination, and generally unsanitary living conditions which accompany flooding would be reduced with implementation of the proposed plan. Also the Chaska waste water treatment plant would be protected from flooding.

68. IMPACTS UPON RECREATION AND AESTHETICS

The proposed levee modifications, flood bypass, and diversion channel are consistent with Chaska's locally developed plans for open spaces and greenbelt corridors. Local interests have indicated that the proposed channels would be incorporated into the plans and that the improvement of the Courthouse Lake area would be especially beneficial to the community. Examples of possible architectural treatments on East Creek at the proposed flood bypass structure and on the proposed Chaska Creek diversion channel are illustrated on plates 7 and 8 of the main report.

69. The aesthetic qualities of the levee will be improved by means of landscape treatments. Since Corps of Engineers standards place certain constraints on levee plantings, accessory berms and special contouring will be provided in order that large woody plants may be placed on or near the levee. The contouring would also decrease the impact of straight lines on the landscape.

70. IMPACTS UPON HISTORICAL AND ARCHEOLOGICAL SITES

The mounds and earthwork or historic sites known from the vicinity of Chaska should not be affected by the project. However, it is noted under paragraph 48, History and Archeology, that the exact site of the Oliver Faribault Fur Post is not known. Investigation into this site would be made during postauthorization studies.

ALTERNATIVE PLANS CONSIDERED

71. GENERAL

A comprehensive and effective plan for managing the floodplains of a particular river basin or locality may include any combination or all of the known measures for flood damage reduction or prevention. Such a program would logically include one or a mix of the following nonstructural and structural measures:

a. Nonstructural measures. -

(1) Flood warning systems.

(2) Permanent evacuation.

(3) Flood proofing of existing or new structures.

(4) Flood insurance.

(5) Floodplain regulation.

b. Structural measures. -

(1) *Reservoir storage.*

(2) Levees and floodwalls.

(3) Channel improvements or diversions.

Based on the above kinds of measures, 14 plans of flood control were developed for Chaska. The plans were analyzed based on an assumed 100-year amortization period and a 5 5/8-percent interest rate. These alternative plans are analyzed in table C-19 and discussed in the following paragraphs.

72. NONSTRUCTURAL ALTERNATIVES

a. Plan 1. - A flood forecasting and flood warning system presently available for the Minnesota River through the National Weather Service and the St. Paul District, Corps of Engineers, provides Chaska city officials and local news media with reliable flood forecasts and warnings. However, little or no warning could be given if intense rainfall caused a flash flood on East and Chaska Creeks. With this alternative the social situation would remain depressed due to the anxiety and worry experienced by local residents during flood seasons and due to the community disruption which occurs during actual floods. Also, the questionable structural integrity of the existing emergency levee system and flash flood potential of East and Chaska Creeks impose an unacceptable high risk of catastrophic damage and potential for loss of life in the community. Accordingly, flood forecasting and flood warnings with subsequent emergency actions are considered to be unacceptable long-term solutions to the Chaska flood problem. The environmental consequences of this alternative would actually be dictated by the existing floodplain regulation at Chaska which is discussed as nonstructural plan No. 5.

b. Plan 2. - Floodplain evacuation, although completely unacceptable to local interests, has been analyzed. Over 540 residences, 47 businesses and industries, and three public buildings are currently within the floodplain. The massive social, institutional, and physical problems make the practicality of this measure very questionable. Community cohesion would be severely disrupted and long-standing sociological and historical ties would be lost. Further, it is questionable whether the remaining urbanized area could continue to function as a viable economic and social unit. The ecological impact would be generally beneficial because much of the floodplain which now supports residential and commercial development could return to the natural ecosystem. This impact is based upon the assumption that all relocations would be made to biological systems which are less sensitive than those of the bottomlands, which would result in a net environmental gain to the natural system. In this regard, floodplain evacuation would be the most preferable of the alternatives in terms of the environmental quality planning objective. However, if the relocations would require alterations of more sensitive biological systems, a net loss to environmental quality could result, requiring a corresponding reduction in its ranking from the standpoint of environmental quality.

c. Plan 3. - Flood proofing of all existing buildings is not practical since most structures are not designed to withstand the high heads involved. Raising the flood-prone structures several feet, when physically possible, and removing structures which are not feasible to raise would entail costs exceeding $19 million. The "perched" appearance of the raised buildings and the massive loss of trees inherent in the flood proofing process would be environmentally unacceptable and aesthetically unappealing. No disturbance of river corridor vegetation or aquatic organisms would be necessary. However, the sociological impacts of flooding, such as disruption of transportation, isolation of residents from their homes and businesses, curtailment of commerce, and potential dangers to public health and safety would remain severe. On these bases, flood proofing would be an inadequate and unacceptable solution to the Chaska flood problem.

d. Plan 4. - Flood insurance is currently available in Chaska for areas subject to flooding from the Minnesota River. A total of 72 properties were protected by the insurance as of April 1973. Flood insurance does not solve the flood problem since it only spreads the monetary loss over a wider population sector and does not reduce the actual damage. The impacts of this alternative would actually be controlled by the existing floodplain regulation which is discussed below as plan 5.

e. Plan 5. - The city of Chaska in cooperation with the State of Minnesota has implemented a floodplain regulation program along the Minnesota River within the city. The East and Chaska Creek floodplains, which have been delineated as part of the present study, will be regulated in the near future. Rather than precluding floodplain development, sound floodplain regulation shapes floodplain land use and

development so as to lessen the damaging effects of floods. Chaska's floodplain regulation program involves the use of legal tools to control the extent and type of future development which will be permitted in the floodplains. With floodplain regulations alone, average annual flood damages would remain high within Chaska because of the dense existing urban developments and the likelihood that urban land use would not appreciably change in the foreseeable future. This leads to the conclusion that floodplain regulation alone could not be expected to minimize total flood hazards representing the costs of any corrective measures plus damages remaining. Accordingly, floodplain regulation is considered a necessary supplement to, rather than a substitute for, appropriate structural and nonstructural flood protective measures in the highly developed urban areas of Chaska. The impact of floodplain regulation upon biological systems and other aspects of the natural environment is mainly to confine certain kinds of cultural development to areas which are less ecologically sensitive than bottomland forests, wetlands, and lakes or streams. In the case of Chaska, the rate of development of areas within the intermediate regional flood outline would be curtailed. On the basis of the environmental planning objective, any nonstructural plan for Chaska which incorporates appropriate floodplain regulation will tend to rank second in preference only to the alternative of permanent floodplain evacuation.

73. STRUCTURAL ALTERNATIVES

a. Plan 6. - Plan 6 includes the diversion of Chaska Creek around the heavily developed areas of Chaska and the provision of a flood bypass for East Creek as described for the proposed plan. The proposed modifications would require earthen embankments to divert the flood flows into rock-lined channels which would carry floods safely to the Minnesota River floodplain. Approximately 28 acres of undeveloped commercial and industrial land would be taken out of production with attendant loss of tax base. In addition, three houses and six mobile homes would require relocation. However, over 100 acres of intense urban development including 284 homes, 18 businesses, two public buildings, the city waste water treatment plant and system, Courthouse Lake, streets, roads, and public utilities would remain subject to flooding from the Minnesota River. Thus, this alternative alone would not provide a complete and adequate solution to Chaska's flood problem. The environmental impacts of this alternative are described as part of the discussion of the selected plan. Maintenance of normal low flows in the existing East Creek channel and possible development of environmental interpretive trails along forested and marshy areas of the creek would enhance human appreciation of the environment.

b. Plan 7. - The upgrading and extension of the existing emergency levee combined with the provision of adequate interior drainage facilities would give intermediate regional flood protection from the Minnesota River. Although the urbanized area behind the levee system would be adequately protected from floods on the Minnesota River, it would have no protection against flash floods on East and Chaska Creeks which could overflow and fill the leveed area from the landward side. In addition, this plan provides no flood protection for urban development along the Chaska and East Creek floodplains. Accordingly, the entire community would remain subject to flood damages from the two creeks. Thus, this alternative alone would not provide a complete and adequate flood damage reduction solution to Chaska's flood problem. The environmental impacts of this alternative are described as part of the discussion of the proposed plan.

c. Plan 8. - This alternative combines the elements of plan 6 with the elements of plan 7 to provide intermediate regional flood protection from all flood sources in Chaska, which comprises the selected plan of improvement discussed earlier in this appendix.

d. Plan 9. - The construction of four headwaters reservoirs at sites which have been previously studied by the U.S. Department of Agriculture, Soil Conservation Service in the East and Chaska Creek watersheds could reduce intermediate regional flood peak flows by approximately 40 percent in Chaska. The benefit-cost ratio would be less than unity and average annual flood damages in Chaska would be reduced by only about 29 percent. The floodplain area behind the existing levee system and much of floodplain areas along the creeks would remain subject to flooding. Thus, this alternative alone would not provide a complete and adequate solution to Chaska's flood problem. Some 600 acres of land, including 100 acres of cropland and 400 acres of wet pasture and marshland would be used. The use of dry dams would conflict with Jonathan Development Corporation plans to construct small, fixed-pool, recreation reservoirs primarily for aesthetic purposes in this area. However, the use of 2- to 5-foot deep sediment pools would increase the value of these lands for game and nongame wildlife.

e. Plan 10. - The four headwaters reservoirs described under plan 9 could be combined with the flood bypass channel, diversion channel, and the upgraded and extended levee system features of plan 8 to provide adequate protection from the intermediate regional flood. This would result in a small reduction in the required size of the diversion and bypass channels as compared to the proposed plan (plan 8). Although both plans would provide nearly identical flood damage reduction, plan 10 is $3.35 million more expensive than plan 8 and results in a significant loss of net benefits. Further, plan 10 would require the acquisition, use, and alterations of about 640 acres of private land as compared to about 40 acres of land with plan 8. Socioeconomic and ecological impacts of plan 10 would be similar to the combination of plans 6, 7, and 9.

f. Plan 11. - Two large earth-fill dams, one on East Creek and the other on West Creek, immediately upstream from where each creek exits into the Minnesota River valley would provide intermediate regional flood protection from the streams. However, the benefit-cost ratio would be only 0.7. Such reservoirs would require the relocation of major trunk sewer lines, a heavily used county road, and several residences. Approximately 70 acres of heavily wooded stream valley would be lost and a planned creek greenway system would be severed.

g. Plan 12. - The two large reservoirs described in plan 11 could be combined with the levee improvements of plan 7 to provide intermediate regional flood protection for the community. The benefit-cost ratio would be 0.7. Socioeconomic and ecological impacts would be identical to those described for plan 7 and plan 11 except this plan would provide an adequate degree of flood protection for the city of Chaska.

h. Plan 13. - Approximately 2.5 miles of channel improvement through Chaska on East and Chaska Creeks constitute this plan. The proposed works would consist of enlarging, deepening, and refinishing the existing channel linings using grass riprap or concrete surfacing or combinations of these materials. The benefit-cost ratio would be 1.5. Substantial ecological changes along East Creek could be expected where about 25 acres of forest would be removed and marshy areas adjacent to the stream would be drained. The large channel required would be generally displeasing aesthetically and difficult to maintain. Approximately 26 residences and three businesses would require relocation and every bridge in Chaska would have to be replaced.

i. Plan 14. - The channel improvement on East and Chaska Creeks as described in plan 13 could be combined with the levee improvement of plan 7 to provide intermediate regional flood protection for Chaska. The benefit-cost ratio would be 1.2, including all benefits associated with flood control. Socioeconomic and ecological impacts would be identical to those described in plans 7 and 13.

74. NO ACTION

Consideration was given to maintaining the status quo or recommending that no action be taken to alleviate flood problems. To do nothing would not burden local interests and the Federal Government with the financial costs associated with other alternatives. Nevertheless, average annual damages estimated at over $800,000 would remain and, as such, would be a severe social and economic burden to the people. Natural riverine aesthetics would probably not change significantly in designated park areas. However, as normal economic

growth occurred, infringement on the river corridor in other areas by businesses, industries, and residences would likely result in degradation of the natural riverscape. Furthermore, provisions for any flood protection would be dependent on the construction of emergency levees and temporary interior drainage facilities. In view of the flash flooding that can occur at Chaska from East and Chaska Creeks, reliance on emergency measures for the entire city would be hazardous during Minnesota River floods and ineffective for flash floods on the two creeks.

APPENDIX G

RECREATION RESOURCES

AUTHORITY

1. Section 4 of the Flood Control Act of 1944 (16 U.S.C. 460d), as amended by Section 207 of the Flood Control Act of 1962, grants general permissive authority to construct recreational developments at all water resource developments under control of the Secretary of the Army (ER 1120-2-404).

PURPOSE

2. This appendix appraises project resources, estimates magnitude and growth of public use and optimum scale of development required to accommodate this use and preserve environmental resources. The appendix also establishes the amount of necessary development, its cost, and location of lands to be acquired for public use.

SCOPE

3. The proposed public-use development consists of a levee trail system and community park at Courthouse Lake in Chaska, Minn. Recreational use will consist of nonmotorized trail use, mainly bicycling, hiking, wildlife photography, nature walks, bird watching, and walking for pleasure. The levee will be aesthetically treated to blend into the natural environment by utilization of native prairie grass and overburden areas. The overburden areas, or warps, will allow a root-free zone permitting establishment of large native trees (EM 1110-2-301). Local interests have indicated a desire and willingness to participate in constructing the proposed trails. They have also indicated an interest in developing a trail system along the Chaska Creek diversion channel and along East Creek to allow interconnection with other contemplated trail systems. However, local planning has not progressed to the point where a detailed trail system can be identified. Further consideration will be given to these recreation needs during postauthorization studies.

BACKGROUND

4. Local interests will be required to participate under provisions of the authorizing document. Details of the precise format are found in the section on management and cost sharing.

DESCRIPTION OF PROJECT AREA

5. GEOGRAPHIC BOUNDARIES

The project includes East and Chaska Creek watersheds and the Minnesota River at Chaska. Chaska is located on the left bank of the Minnesota River (mile 29.6).

6. CLIMATE

The mean temperature varies from 74° F in July to 14° F in January. Extremes of 109° F and -43° F have been recorded. Average annual precipitation is 27 inches, including an average annual snowfall of 44 inches.

7. TOPOGRAPHY, GEOLOGY, AND LAND USE

The floodplain, at elevations 705 to 725 feet, is approximately 1 mile wide. A prominent bench rises out of the river bottom at elevation 750. From this terrace the valley walls rise steeply to form a bluff at elevation 850 to 900.

8. The glacial history of Chaska is quite pronounced. A thick deposit of outwash sands and unsorted tills forms a hummocky, poorly drained plain dotted with marshes and small lakes. The glacial drift is 200 to 250 feet thick and rests on dolomite and sandstone of the Prairie du Chien and Jordan Formations. Additional data on geology can be found in Appendix A, Geology, Soils Data, and Analysis.

9. The 490 acres of floodplain at Chaska are 27 percent residential, 15 percent commercial, 5 percent streets and railroads, 3 percent public property, and 50 percent currently undeveloped.

10. BIOLOGIC AND ECOLOGIC FEATURES AND RESOURCES

The area is within the Maple-Basswood complex of the Northern Hardwood Forest, primarily called the "big woods." The Northern Hardwood Forest appears to be related to the fine gray drift soils from the Keewatin ice center.[(1)] Common upland trees include bur oak, white oak, red oak, black oak, elm, basswood, ash, maple, hornbeam, aspen, birch, wild cherry, and hickory. Small trees include dogwood, sumac, crabapple, black haw, and wild rose. The wetlands are of marginal quality for waterfowl and may actually be improved by establishment of the levee, which may tend to hold more water in the vicinity.

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(1) Daubenmire, R. F., 1936, "The Big Woods" in Minnesota: Its Structure and Relationship to Climate, Fire and Soils, Ecological Monographs 6:235-268, 1936.

11. ACCESSIBILITY

The area is easily accessible via State Highway 41 and U.S. Highway 212. Air transportation would be provided via the Flying Cloud Airport at Eden Prairie, Minn., and the Minneapolis-St. Paul International Airport 20 miles east of Chaska.

12. ATTRACTIONS OF AREA

The Minnesota River valley trail and the Jonathan area when developed will attract local as well as regional recreation use. Further data are contained later in the report.

PROJECT DATA

13. The project consists of 9,250 feet of levee varying from 20 to 25 feet in height. Interior drainage is accommodated by four pumping stations. Chaska Creek will have a 0.9-mile diversion channel which will be lined with riprap and concrete. The East Creek area will have a 1.2-mile-long, trapezoidal-shaped flood by-pass channel. Normal low flows will be maintained in the existing East Creek channel.

RECREATION MARKET AREA

14. RECREATIONAL ZONE OF INFLUENCE

The area that can be expected to contribute 80 percent of day use is called the zone of influence. In this project, demand will basically be of local origin and will include only the Chaska-Jonathan area. Some additional visitation can be expected to occur due to the close proximity of the Minnesota River trails, which will be connected to the proposed Chaska-Jonathan trail.

15. SOCIOECONOMIC CHARACTERISTICS OF THE MARKET AREA

Current population within the zone of influence is shown on table G-1.

Table G-1 - Zone of influence population[1]

Area	Population
Chaska	2,902
Jonathan	1,450
Total	4,352

(1) 1970 Census of Population, Number of Inhabitants, Minnesota, August 1971, U.S. Department of Commerce, Bureau of Census, Washington, D.C.

16. Jonathan is a rapidly developing planned community located within the city of Chaska. A rather substantial increase in population is expected within the zone of influence by the year 2000, due to an expected influx of new residents to Jonathan. Anticipated growth patterns are included in the economics appendix. Projected population within the zone of influence is shown in table G-2.

Table G-2 - Projected population within zone of influence[1]

Year	Population
1970	4,300
1975	12,100
1980	27,800
1985	47,900
1990	63,000
1995	73,000
2000	80,000
	Saturation 85,000

(1) Report on Comprehensive Sewer Study for Chaska, Minn., Bonestroo, Rosene, Anderlik and Associates, Inc., St. Paul, Minn., 1971, page 20.

17. The growth of leisure time and recreational demand has been great, as table G-3 demonstrates. To express the trend in terms of the national time budget, Clawson and Knetsch[1] demonstrate the growth, as shown on figure G-1.

(1) Clawson, Marion and Knetsch, Jack L., Economics of Outdoor Recreation, John Hopkins Press, Baltimore, 1966.

Table G-3 - National time budget and time division of leisure, 1900, 1950, and 2000

Use of time	1900 Billion hours	1900 Percent of total time	1900 Percent of leisure time	1950 Billion hours	1950 Percent of total time	1950 Percent of leisure time	2000 Billion hours	2000 Percent of total time	2000 Percent of leisure time
Sleep	265	40		514	39		1,131	39	
Work	86	13		132	10		206	7	
School	11	2		32	2		90	3	
Housekeeping	61	9		68	5		93	3	
Preschool population, non-sleeping hours	30	4		56	4		110	4	
Personal care	37	6		74	6		164	6	
Total	490	73		876	66		1,794	62	
Remaining hours, largely leisure									
Daily leisure hours	72		41	189		42	375		34
Weekend leisure hours	50		28	179		39	483		44
Vacation	17		10	35		8	182		16
Retired	6		3	24		5	56		5
Other, including unaccounted	32		18	26		6	16		1
Total remaining hours, largely leisure	177	27	100	453	34	100	1,113	38	100
Total time for entire population	667	100		1,329	100		2,907	100	

SOURCE: Adapted from Mary A. Holman, "A National Time-Budget for the Year 2000," Sociology and Social Research, Vol. 46, No. 1 (October 1961).

LEISURE IN MODERN AMERICA

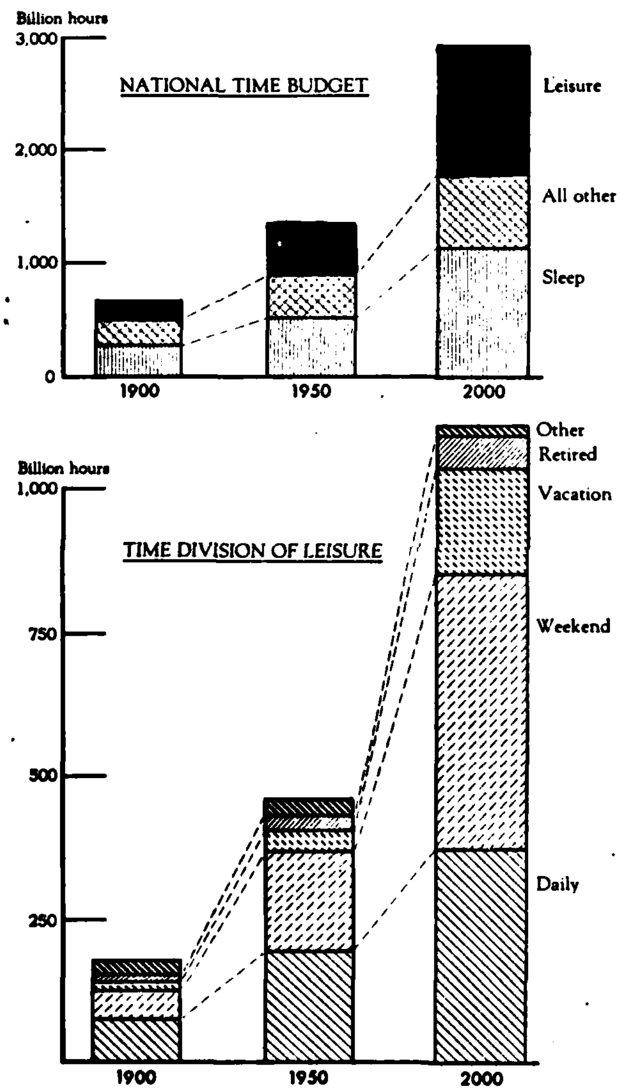


Fig G-1

18. It is possible that this project may attract recreationists from outside the State, particularly from Wisconsin. However, this visitation is not likely to be significant, because of the local origin of the expected usage. As a result, no recreation benefits can be directly attributed to out of State users.

19. The need for nonmotorized pedestrian pathways is rapidly increasing. An estimated 12.2 million bicycles were sold in this country in 1971. Approximately 150,000 bicycles were sold within the Twin Cities seven-county metropolitan area in 1972, and retailers had difficulty meeting this demand. Reports indicate sales are at record levels again in 1973. The past few winters there has also been a "boom" in purchases of cross-country skiing equipment and snowshoes, as people perceive a cheaper and more acceptable alternative to the snowmobile for recreation. Other forms of recreation are also increasing dramatically. This section will demonstrate how some less noticeable forms of outdoor recreation are also increasing. Many reasons can be cited for these activities gaining in popularity, among them:

a. There is an increased concern about our environment and man's effect on it by unnecessary use of machines.

b. The relative low cost of necessary equipment and maintenance is attractive.

c. These activities are easily engaged in by all ages and are thus carried over throughout a lifetime, and thus can be considered lifetime sports.

d. Proficiency in these activities is relatively easy to achieve. Many people need only to try the activity once to achieve their desired proficiency level.

e. The activities provide excellent exercise, and provide a very enjoyable method of combining exercise and pleasure.

f. There are no user fees so the initial equipment cost is usually the only expense.

g. They are quiet recreation pursuits that enable participants to view nature on its own terms. They provide a tremendous opportunity for increased environmental awareness.

20. Present opportunities for bicycling and hiking within the area are somewhat limited. When Jonathan is completed, more trails will be available, but still not enough to meet the demand. A few trails currently exist within Jonathan, but for the most part they do not now interconnect.

21. As previously illustrated, demand for outdoor recreation facilities is increasing. Bicycling increased 105 percent from 1960 to 1967 in terms of activity occasions within the State. In 1967 there were 10.6 million bicycle activity occasions, and an increase to 23.7 million is expected by 1985. Considering adult demand alone, there was a need for 5,800 additional miles of bicycle trails in 1967, and nearly 12,000 more miles of trails will be needed by 1985.[1] There is a tremendous need for bicycle trails within the State and this project could aid in providing a vitally needed facility.

22. The project will be able to satisfy a percentage of recreation demand for each activity as shown in table G-4. These percentages, as well as the recreation analysis, use only the old city of Chaska as a base.

Table G-4 - Percentage of demand project will satisfy

Activity	Percent
Bicycling	10
Nature walks	20
Walking for pleasure	20
Bird watching	15
Wildlife photography	10
Hiking	10

23. The establishment of pedestrian greenways[2] within the Jonathan area will allow development of a unique trail system connecting the following elements which now function separately: (plate G-3)

a. Hennepin County Park Reserve at Carver, Minn.

b. University of Minnesota Arboretum.

c. Jonathan area.

d. Chaska area.

e. Access to Minnesota River valley trail system.

The proposed pedestrian greenways in Jonathan and Chaska will provide a means to link all of these elements. The levee trail system would allow recreationists access to the Minnesota River valley trail system, giving the area regional instead of local recreational significance.

(1) Minnesota Outdoor Recreation Plan, Bureau of Planning, Department of Conservation, State of Minnesota, June 1969.
(2) Map of open space program for Chaska, City of Chaska, Minn.

Travel from Chaska to Jonathan and then to either Carver Park or the University Arboretum could be done using several different routes. Numerous access points along the trail would allow people to travel distances of from 2 to 10 miles.

24. The East Creek area could serve as an excellent outdoor laboratory for the Chaska elementary and senior high schools, which own land adjoining the stream. Unique opportunities exist for demonstrating many nature interpretive programs in the wooded areas along East Creek. Also, severe soil erosion near the clay pit as well as other environmentally degrading situations could be demonstrated. An excellent setting for demonstrating many diverse biotypes exists within the East Creek area. A tremendous opportunity exists for not only formal classroom use but also for use by the general public. Possibly an advanced high school biology class could operate a nature center.

25. Nature interpretive centers within the area receive heavy use throughout the year. The visitation shown in table G-5 is high because of available facilities. No assumption is made as to the precise annual attendance, if a program were established. Table G-5 shows considerable interest is present and a program would attract people. Students could lead nature walks throughout the year. Snowshoe and cross-country interpretive hikes, as well as moonlight and sunrise jaunts are very popular in the winter. An enthusiastic teacher and some dedicated students could produce an outstanding program offering unique educational experience for all concerned.

Table G-5 - Visitation to nature centers within the Chaska area

Area	Annual visitation
Hyland Lake Park Reserve, Bloomington, Minn.	20,000
Carver County Park, Victoria, Minn.	40,000
Woodlake Nature Interpretive Center, Richfield, Minn.	60,000
University of Minnesota Arboretum	100,000
Total annual visitation	220,000

DETERMINATION OF OUTDOOR RECREATIONAL ATTENDANCE

26. PER CAPITA PARTICIPATION RATES

The six activities shown in table G-6 will constitute the majority of use on the project. No winter activities have been included because no data are presently available on participation rates. Thus, the actual use of the levee will be somewhat higher than is shown.

Table G-6 - Participation rates[1]

Activity	1980	2000	2020
	Year		
Bicycling	6.00	6.48	6.97
Nature walks	1.00	1.08	1.13
Walking for pleasure	6.79	7.64	8.60
Bird watching	1.10	1.19	1.28
Wildlife photography	0.19	0.22	0.28
Hiking	0.49	0.61	0.78

(1) Bureau of Outdoor Recreation, West North Central Participation Rates, 1969.

27. INITIAL ANNUAL ATTENDANCE

Table D-7 utilizes the above data along with the population of the old city of Chaska (effective zone of influence) to calculate the total annual activity occasions within the zone of influence. These data were placed in graphic form in figure G-2 to demonstrate initial attendance 3 years after project completion.[1]

Table G-7 - Total annual activity occasions within zone of influence

Activity	1980 Population-4,778		2000 Population-7,193		2020 Population-11,086	
	Participation rate[1]	Total annual activity occasions[2]	Participation rate[1]	Total annual activity occasions[2]	Participation rate[1]	Total annual activity occasions[2]
Bicycling	6.00	28,668	6.48	46,611	6.97	77,269
Nature walks	1.00	4,778	1.08	7,768	1.13	12,527
Walking for pleasure	6.79	32,443	7.64	54,955	8.60	95,340
Bird watching	1.10	5,256	1.19	8,560	1.28	14,191
Wildlife photography	0.19	908	0.22	1,582	0.28	3,104
Hiking	0.49	2,341	0.61	4,388	0.78	8,647
Total		74,394		123,864		211,078

(1) Bureau of Outdoor Recreation, West North Central Participation Rates, 1969.
(2) Total annual activity occasions = participation rate X population.

(1) $\frac{\text{Activity occasions}}{2.5}$ = recreation days.

Expected Visitation at Chaska Levee Trail System

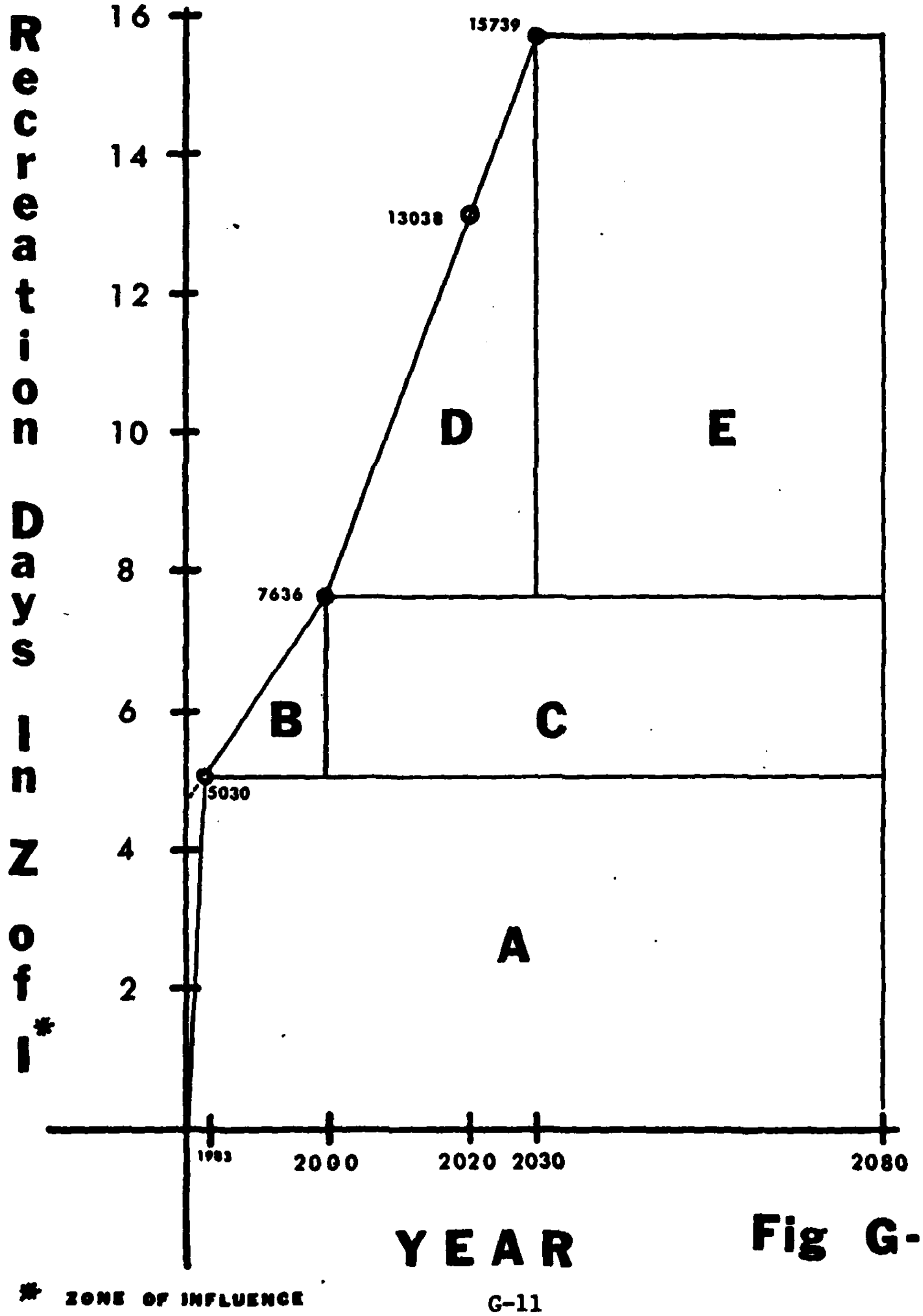


Fig G-2

* ZONE OF INFLUENCE

28. ESTIMATED ATTENDANCE AT PROJECT

All activity occasions cannot be attributed to the project, since not all projected activity occasions within the zone of influence would occur on the levee. Therefore, an adjustment was made in table G-7. The percentage of use column reflects that percentage of the total activity occasions that could be expected to occur on the levee. The difference between the 85 percent and unity is attributable to nonmotorized winter use, such as snowshoeing and ski touring, for which no accurate use data are available, no benefits are considered, and no additional facilities are necessary to accommodate the uses. The totals were then divided by 2.5 to convert to recreation days, as shown in table G-8.

Table G-8 - Total adjusted annual activity occasions within the zone of influence

Activity	Percentage of use	Year 1980	Year 2000	Year 2020
Bicycling	10	2,867	4,661	7,726
Nature walks	20	960	1,550	2,500
Walking for pleasure	20	6,490	10,990	19,070
Bird watching	15	790	1,290	2,130
Wildlife photography	10	90	160	310
Hiking	10	230	440	860
Total	85	11,427	19,091	32,596
Recreation days (1)		4,570	7,636	13,038

(1) $\frac{\text{Activity occasions}}{2.5}$ = recreation days.

29. AVERAGE ANNUAL ATTENDANCE

A standard economic analysis and an interest rate of 5½ percent were utilized to convert annual recreation days to average annual recreation days. The following methodology refers to figure G-2.

Area A = 5,030 X 0.9475 = 4,766

Area B

Rate of increase per year	153.3
Value of increasing annuity for 17 years	82.95
Present worth of 1 - 3 years hence	0.8486
Interest and amortization over 100 years	0.05649

153.3 X 82.95 X 0.8486 X 0.05649 = 610

Area C

Constant value of 3,066 for 80 years		
Value of constant amortization of 1 for 80 years		17.55
Present worth of 1 - 20 years hence		0.3347
Interest and amortization over 100 years		0.05649
3,066 X 17.55 X 0.3347 X 0.05649	=	1,017

Area D

Rate of increase per year		270.1
Value of increasing annuity for 30 years		165.91
Present worth of 1 - 20 years hence		0.3347
Interest and amortization over 100 years		0.05649
270.1 X 165.91 X 0.3347 X 0.05649	=	847

Area E

Constant value of 8,103 for 50 years		
Value of constant amortization of 1 for 50 years		16.63
Present worth of 1 - 50 years hence		0.0681
Interest and amortization over 100 years		0.05649
8,103 X 16.63 X 0.0681 X 0.05649	=	518
Area A	=	4,766
Area B	=	610
Area C	=	1,017
Area D	=	847
Area E	=	518
Average annual recreation days	=	7,758

Average annual recreation benefits are derived by applying a unit value of $0.50 per recreation day.

7,758 X $0.50 = $3,879 average annual recreation benefits

30. ADDITIONAL REAL ESTATE NEEDED FOR RECREATION

Chaska is purchasing numerous tracts of land along the stream bottoms to be reserved as open space. A future trail is proposed along the East Creek section. Federal assistance could possibly be made available at that time. East Creek will be used as a low-flow channel, thus making the addition project-related.

RECOMMENDED PLAN OF DEVELOPMENT

31. TYPE OF USE EXPECTED

Six previously mentioned activities can be anticipated at the project. A tremendous amount of unsatisfied recreation demand exists in terms of "trail use". Establishment of a quality trail will encourage use not only by people who already participate in these activities, but also by new users.

32. PROPOSED DEVELOPMENT

The project will include a trail system along the top of the levee and beautification of the project within the old city of Chaska. Where riprap is not required for erosion control, the levee should be seeded to native prairie grass species, which grow to a height of approximately 6 to 8 inches and require virtually no maintenance. Because burning would not be possible, only prairie species that can be established without burning would be used.

33. An 8-foot-wide asphalt path would be established along the top of the levee and would extend from the western edge of the Chaska levee to Courthouse Lake, and then continue around the lake in a short loop(plate G-1). The levee would continue past Courthouse Lake and tie into high ground a few hundred yards beyond. Plate G-2 shows a detail of how the exiting levee will connect with the proposed levee, providing usable space for recreational activities. Chaska could easily maintain picnic grounds at Courthouse Lake as an area for passive recreational pursuits. An overburden area (as described in EM 1110-2-301, 29 December 1972) is shown which would not affect the structural integrity of the levee, but would add to the attractiveness of the project in this area. By incorporating this overburden area, native floodplain vegetation would be allowed to grow up the sides of the levee and create a natural-appearing site conducive to birding, walking, and other activities.

34. Paving the trail would encourage bicycle traffic. It is hoped that by encouraging bicycle use of the levee trail, present congestion and conflict between automobiles and bicycles in Chaska would be somewhat alleviated. The trail will also encourage use and create a desirable flow pattern. Courthouse Lake will serve as a city park, and people could take lunches on their bicycles and ride to the park. Ample parking currently exists near the lake

which would encourage people to drive there and then bicycle around the lake or to other portions of the area. The paved pathway around the lake would also encourage use by handicapped people, including those confined to wheelchairs.

35. MIX OF ACTIVITIES

A potential problem is undesirable forms of motorized recreational use of the project. It is incongruent to establish greenways to provide pathways throughout the area and then permit machines to overrun the area. To encourage people to enjoy the area by hiking and bicycling, via the trail system, and then to allow interruption by noisy, smelly machines is not acceptable. The project sponsor would be expected to prohibit access to motorized vehicles if the recreation features are constructed.

36. FACILITY LOAD CRITERIA

The six activities listed in table G-8 would create a total annual activity occasion use of about 32,596 for the year 2020. This assumes maximum use based upon one person engaging in only one activity per visit. An estimate of the heaviest use of the trail was determined as follows:

a. $\dfrac{\text{32,596 annual activity occasions}}{\text{180 recreation day season}}$ = 181 activity occasions per season day

b. $\dfrac{\text{181 activity occasions per season day X 7 days per week X 0.60}^{(2)}}{\text{2 days per weekend}}$ =

380 activity occasions per weekend day

c. $\dfrac{\text{380 X 0.80}^{(3)}}{\text{4 hours of peak use per weekend day}}$ = 76 people per hour on peak weekend day

Using the reported capacities of 850 to 1,000 cyclists per hour, as shown in the "Bikeways Planning Criteria and Guidelines," School of Engineering, University of California at Los Angeles, April 1972, the estimate of 76 users per hour for the proposed trail is an acceptable level of use.

(1) Table G-8 - assuming a maximum use of 1 person per activity.
(2) Sixty percent of the recreational use would occur on the weekend.
(3) Assuming 80 percent of peak use would occur during 4 hours, i.e., 1 p.m. to 5 p.m. on weekend days.

37. FISH AND WILDLIFE CONSERVATION AND ENHANCEMENT

Fish and wildlife would be slightly and indirectly benefited by construction of the levee around Courthouse Lake. The lake has a "put and take" trout fishery. During floods it receives water and debris and undesirable rough fish from the Minnesota River. The proposed levee would eliminate flooding by protecting the lake, therefore preventing entrance of rough fish and debris.

38. FOREST RESOURCES AND OTHER VEGETATION PROGRAMS

The only vegetation programs would be as mentioned in paragraph 32, particularly the prairie grass establishment and utilization of an overburden or warp area.

COORDINATION WITH OTHER AGENCIES

39. The following agencies have participated in coordination with this project.

a. Federal. -

Bureau of Outdoor Recreation
Bureau of Sport Fisheries and Wildlife
Soil Conservation Service
Environmental Protection Agency

b. State. - Minnesota Department of Natural Resources

c. County. -

Hennepin County Park Reserve District
Carver County

d. Local. - City of Chaska

The general feeling concerning the project is positive. The concept of establishing greenways and a levee trail system is favorable. The Bureau of Outdoor Recreation especially noted that linkage with the Minnesota River valley trail is very desirable.

IDENTIFICATION OF SPECIAL PROBLEMS

40. There is no potential for encroachment, primarily because of the project's nature as a levee project.

41. The trail would be paved and access points would have gentle grades, so wheelchair patients and the elderly would be able to enjoy the Courthouse Lake area. Ramps, necessary for bicycles to enter existing parking lots, would be natural entrance points for wheelchairs.

42. No conflicts presently exist concerning the proposed levee trail system and any other agency programs.

MANAGEMENT AND COST SHARING

43. CORPS RESPONSIBILITY

Section 4 of the Flood Control Act of 1944 (16 U.S.C. 460 d), as amended by Section 207 of the Flood Control Act of 1962, grants general permissive authority to construct recreational developments at all water resource developments.(1) This law requires matching local participation in terms of money and/or lands that will equal the Federal share. If the local interests are not financially capable of participating, no Federal recreational development will be provided.

44. NON-FEDERAL RESPONSIBILITIES

The non-Federal entity must provide fee title to all additional lands required for development and control of the recreation areas. Where the appraised value of lands provided amounts to less than 50 percent of the total first cost of the recreational development, the non-Federal sponsor must make additional contributions sufficient to bring the non-Federal share to at least that level. (This additional contribution may consist of the actual cost of carrying out an agreed-upon portion of the development, or a cash contribution at the time of construction, or a combination of both.) The entity must operate, maintain, and replace without expense to the Federal Government the recreational areas and all installed facilities. If long-term repayment is elected, however, all costs, including interest, must be repaid within 50 years of the date of first use of the initial recreation facilities. Future expansion or development of new areas will require repayment of costs over the time left in the original contract. If all or part of long-term repayment of the non-Federal share of initial separable costs is to be financed through user fees, the schedule of such fees and the portion thereof dedicated to repayment are subject to renegotiation at intervals not exceeding 5 years. User fees, if collected, can also be used for maintenance and operation. Monies received from non-Federal interests shall be deposited in the Treasury as miscellaneous receipts. Inclusion of recreation development in proposed or authorized projects requires coordination of planning with concerned non-Federal public bodies at all stages. The appropriate non-Federal public body will be requested to furnish assurances of its willingness and ability to meet conditions proposed for non-Federal assumption of responsibilities for development, operation, maintenance, and replacement of recreational facilities. A letter signed by a responsible official should

(1) ER 1120-2-404, 14 August 1970, section 4b, page 3.

state the intention to participate in recreational development of a project, and to share in costs thereof, as proposed in survey reports or design memoranda at the time requested by the Chief of Engineers. A contract will be executed between the Federal Government and the cooperating non-Federal public body, or bodies, specifying agreed-upon scale of development and the financial and managerial responsibilities of the parties for project recreation.

ENVIRONMENTAL QUALITY

45. The environmental quality of the project will determine to a large degree its public acceptance. Extreme care in establishment of prairie grass and overburden areas is necessary for the project to appeal to the recreationist. The utilization of additional overbuilt sections along the levee would be extremely valuable in blending the levee as much as possible into the surrounding vegetation. Plate G-2 shows conceptually how these sections may be utilized.

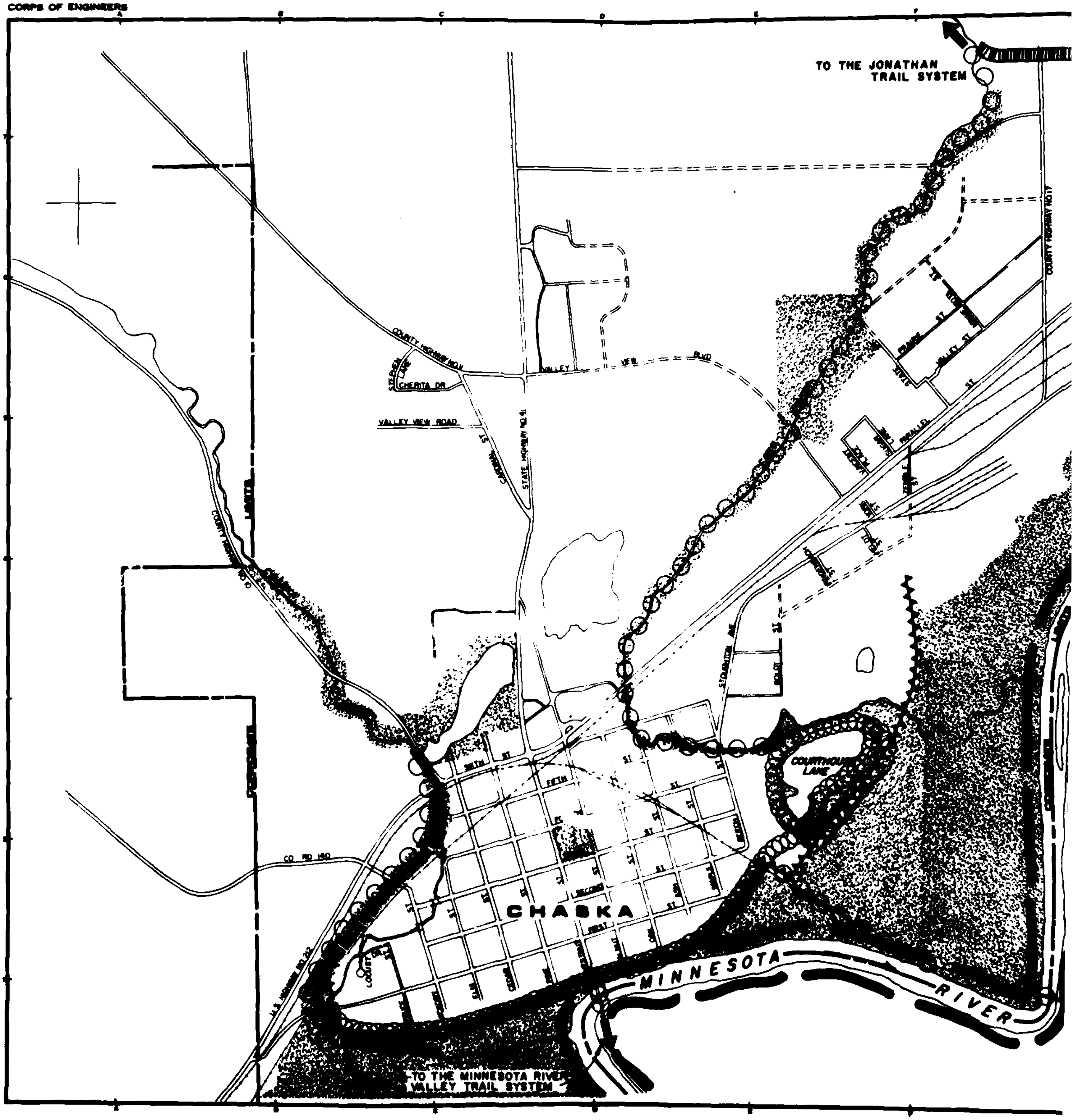
COSTS

46. Table G-9 is a cost estimate for providing the recreational trail along the levee.

Table G-9 - Cost estimate, recreational trail along levee, Chaska, Minn.

Item	Unit	Quantity	Unit cost	Total estimated cost
Paving levee (1 mile, bituminous)	Job	Sum	-	$11,600
Upgrading existing levee around Courthouse Lake and extending trail (1,200 feet)	Job	Sum	-	11,400
Landscaping	Job	Sum	-	3,000
Total construction cost				26,000
Contingencies				5,000
Engineering and design				3,000
Supervision and administration				2,000
Total cost				36,000

CORPS OF ENGINEERS



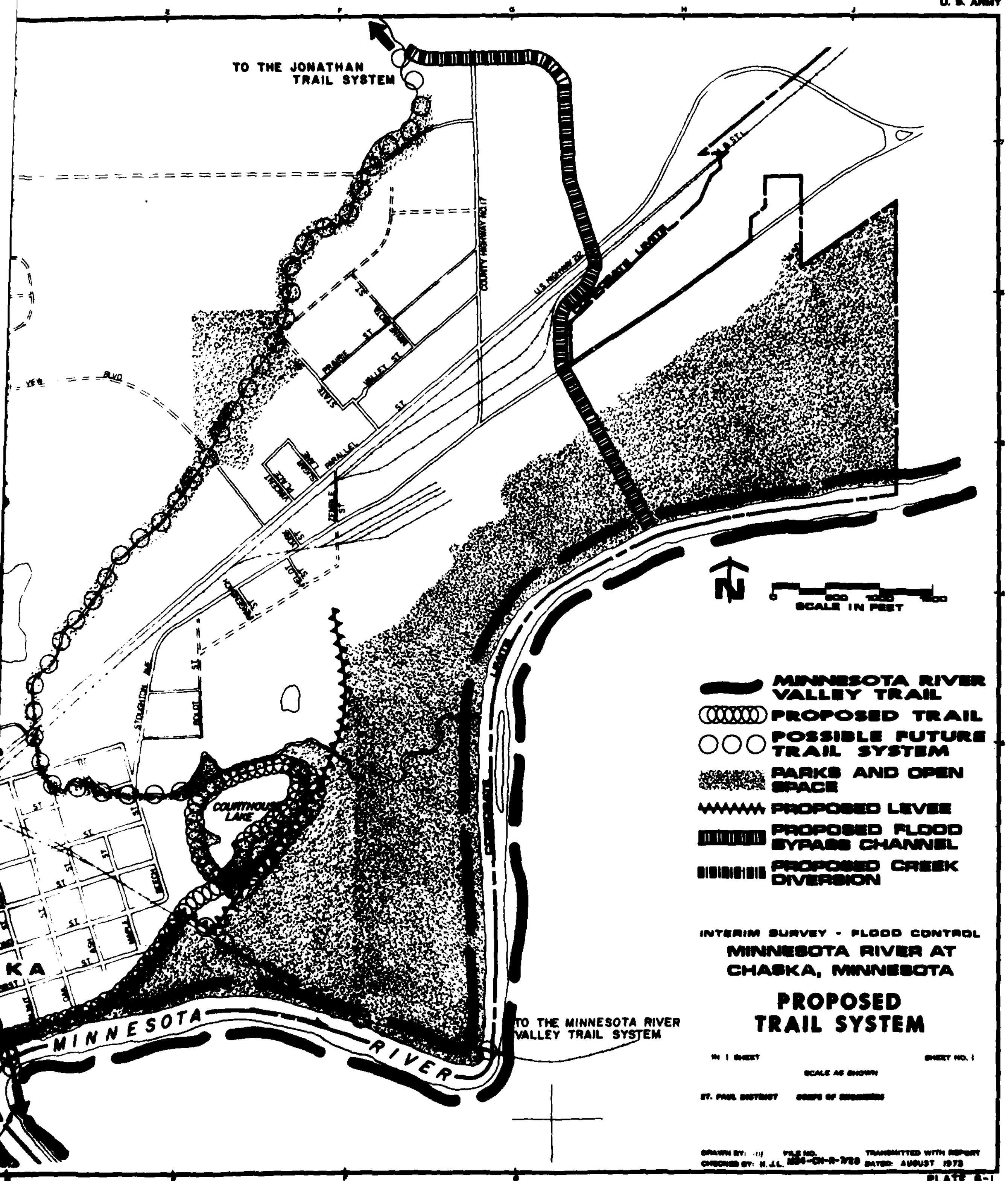
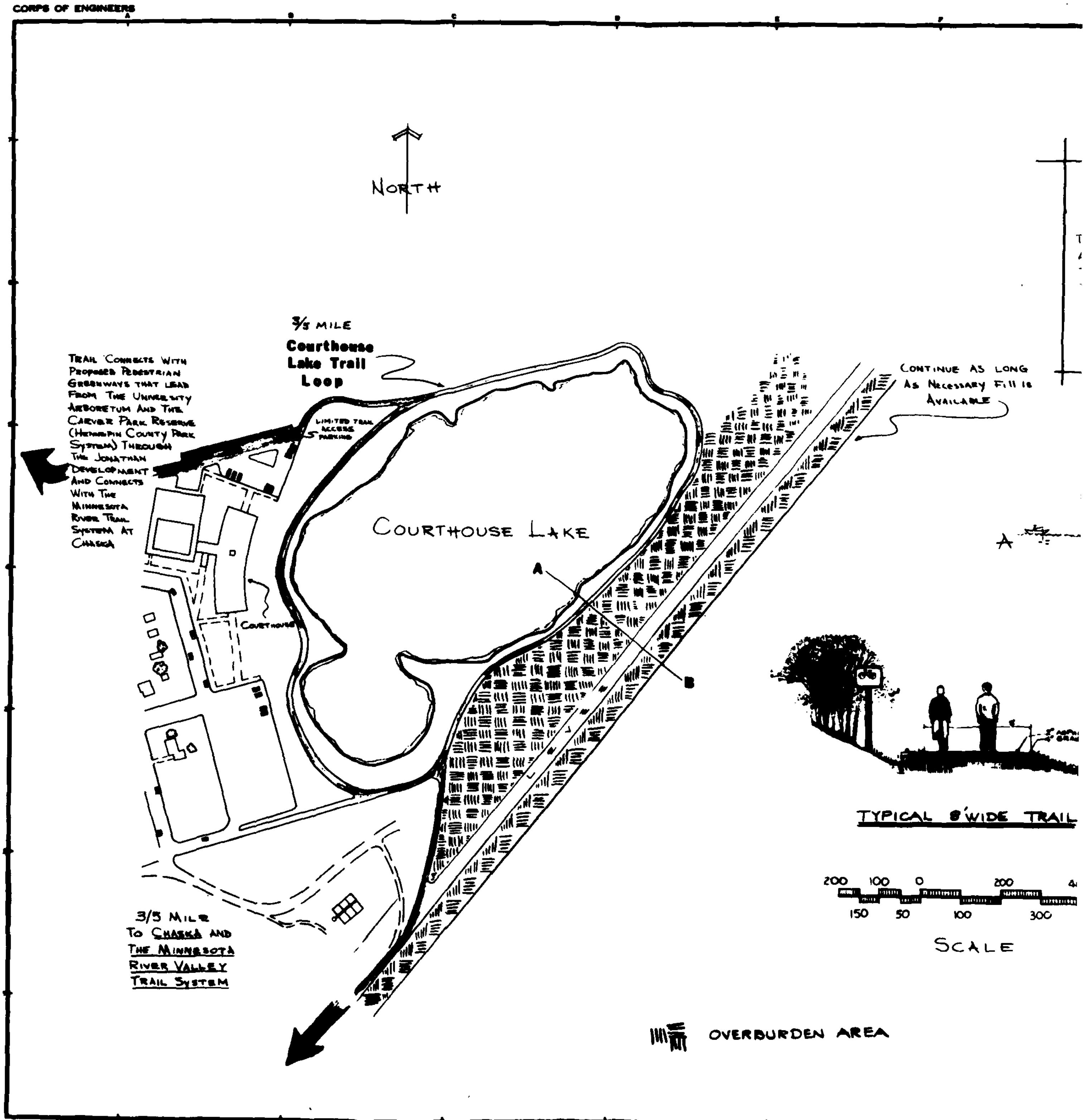

TO THE JONATHAN TRAIL SYSTEM
COUNTY HIGHWAY NO. 17
U.S. HIGHWAY 212
PRAIRIE ST
VALLEY ST
PARALLEL
STOUGHTON AVE
COURTHOUSE LAKE
MINNESOTA
RIVER
TO THE MINNESOTA RIVER VALLEY TRAIL SYSTEM
SCALE IN FEET
0
500
1000
1500
MINNESOTA RIVER VALLEY TRAIL
PROPOSED TRAIL
POSSIBLE FUTURE TRAIL SYSTEM
PARKS AND OPEN SPACE
PROPOSED LEVEE
PROPOSED FLOOD BYPASS CHANNEL
PROPOSED CREEK DIVERSION
INTERIM SURVEY - FLOOD CONTROL
MINNESOTA RIVER AT CHASKA, MINNESOTA
PROPOSED TRAIL SYSTEM
SHEET NO. 1
SCALE AS SHOWN
DRAWN BY:
FILE NO.
TRANSMITTED WITH REPORT
CHECKED BY: H.J.L.
DATED: AUGUST

PLATE 6-1

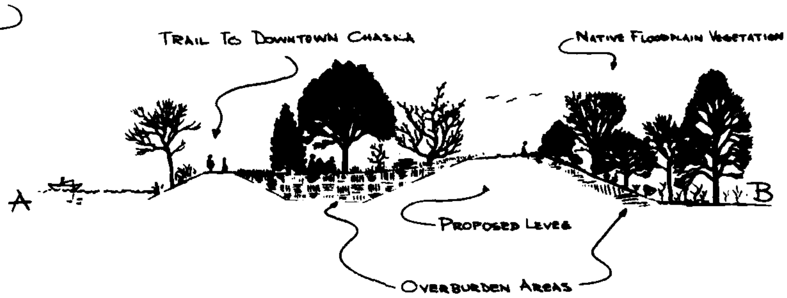
2

CORPS OF ENGINEERS



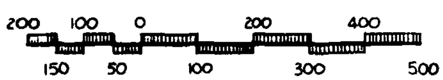
NOTE

The Proposed Levee Contains An "Overburden Area" As Specified in EM 1110-2-301, 29 Dec 72. This Will Allow The Native Floodplain Vegetation To Grow Unmolested And Therefore Natural Succession Will Eventually Establish A Native Ecological Biotype. Native Prairie Grasses Will Be Seeded.



CROSS SECTION
(NO SCALE)

TYPICAL 8' WIDE TRAIL



SCALE

OVERBURDEN AREA

DEPARTMENT OF THE ARMY

JDT ELM
JDT ELM
N.J.L.

INTERIM SURVEY- FLOOD CONTROL
MINNESOTA RIVER AT
CHASKA, MINNESOTA
Courthouse Lake Trail

DATE: AUGUST 1973

AS SHOWN

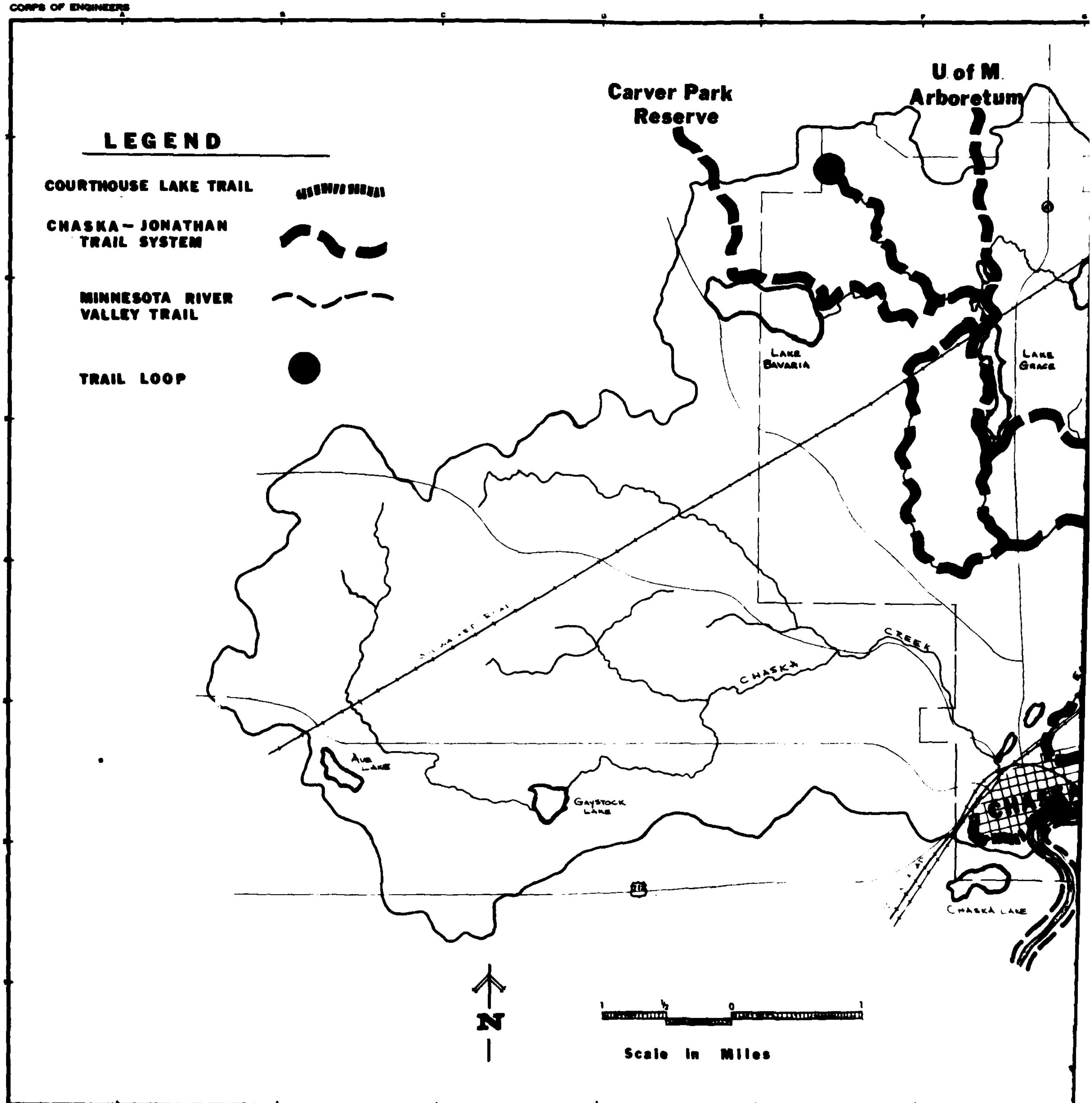
M34-CH-R-7/29

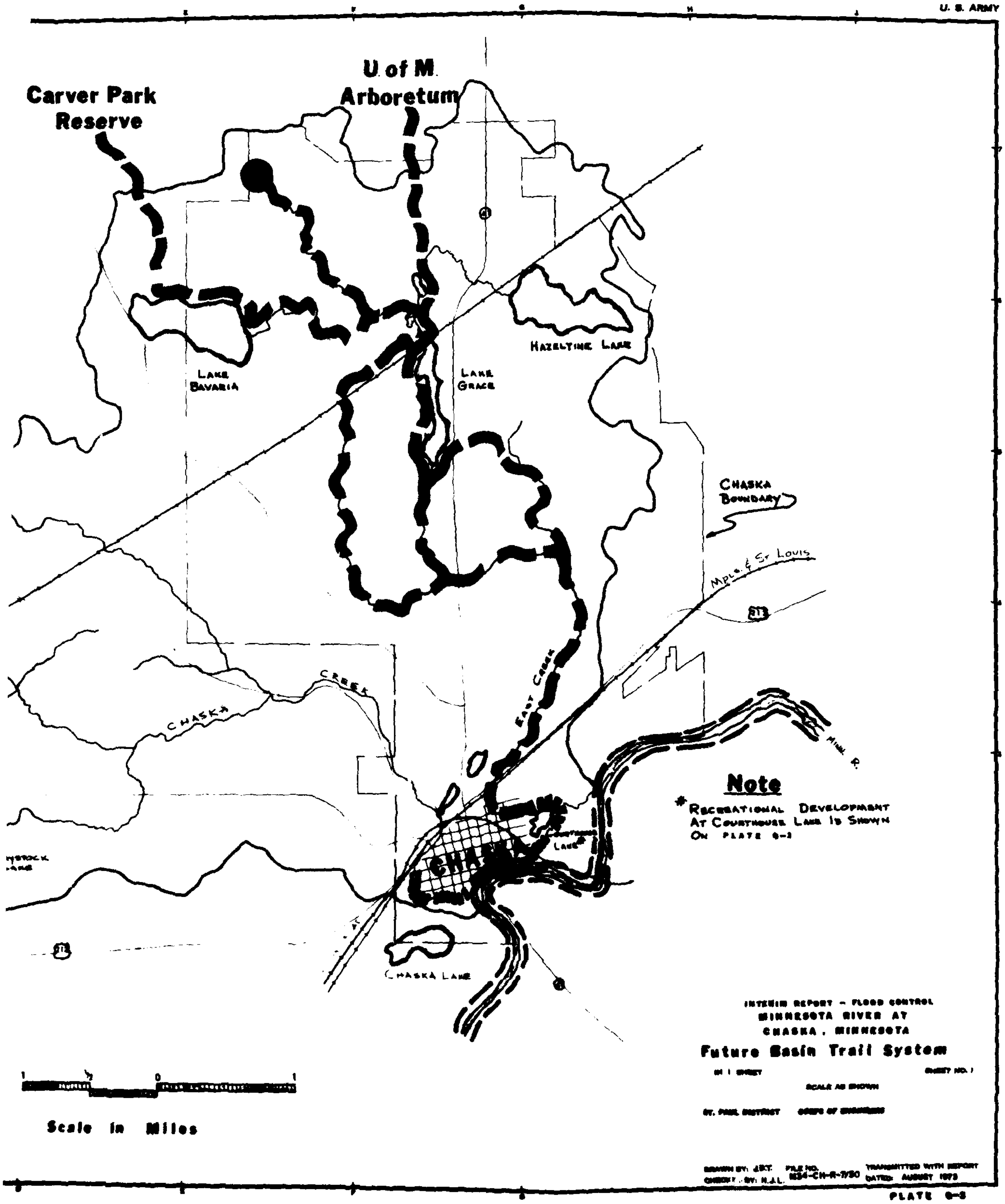
SHEET 1 OF 1

PLATE 6-2

2

CORPS OF ENGINEERS





Carver Park Reserve
U of M Arboretum
Lake Bavaria
Lake Grace
Hazeltine Lake
Chaska Boundary
Mpls & St Louis
East Creek
Chaska Creek
Chaska Lake
Note
* Recreational Development At Courthouse Lake Is Shown On Plate
Scale in Miles
Interim Report - Flood Control
Minnesota River at
Chaska, Minnesota
Future Basin Trail System

PLATE

2

APPENDIX H

COMMENTS OF OTHER AGENCIES AND INTERESTS

This appendix presents the views and comments of other Federal agencies and non-Federal interests with discussion thereof relative to the recommended improvements for flood control at Chaska, Minn. The draft interim survey report was sent to the following agencies, organizations, and interested citizens for review and comment:

U.S. Soil Conservation Service
U.S. Department of Transportation, Federal Highway Administration
U.S. Department of the Interior
  Bureau of Sport Fisheries and Wildlife
  Bureau of Outdoor Recreation
  U.S. Geological Survey
U.S. Department of Housing and Urban Development
U.S. Environmental Protection Agency
National Weather Service
U.S. Department of Health, Education and Welfare
Minnesota Department of Highways
Minnesota Pollution Control Agency
Minnesota Department of Natural Resources
Minnesota State Planning Agency
State Liaison Officer for the National Park Service
Department of Anthropology, University of Minnesota
Chicago, Milwaukee, St. Paul and Pacific Railroad Company
Chicago and North Western Transportation Company
Lower Minnesota River Watershed District
Southern Minnesota Rivers Basin Commission
Minnesota River Watershed Association

Comments were received from the following:

a. U.S. Soil Conservation Service. -

Comment. - The Soil Conservation Service expressed no objection to the proposed plan. Suggested additions to the report follow:

> Maps, scale 1:15,840, are available for the project area. The Carver County Soil and Water Conservation District has been working to develop a good land treatment program and intends to work closely reviewing site plans for future urban uses in the watersheds. Erosion and sediment controls should be implemented on new construction sites.

Discussion. - The report was revised to include the above suggestions.

b. Federal Highway Administration. -

Comment. - The Federal Highway Administration notes that the project does not require relocation of highways, but structure modification and new structures over bypass and diversion channels would be necessary. The costs associated with these structural changes are not eligible for Federal aid highway funds as correctly stated in paragraph 85. However, the reference in that paragraph to U.S. Bureau of Public Roads should be changed to Federal Highway Administration. Minor numerical changes might be desirable on page 29, table 8, to change the standard project flood for Chaska Creek discharge from 9,000 cfs to 16,500 cfs and on page B-17, paragraph 42, from 14,700 cfs to 4,700 cfs for the intermediate regional flood.

Discussion. - Comments were noted and appropriate modifications were made to the report.

c. U.S. Bureau of Sport Fisheries and Wildlife. -

Comment. - The Bureau of Sport Fisheries and Wildlife does not oppose the proposed plan. The Bureau favors greenbelt acquisition and Minnesota River floodplain regulations required by the plan. Specific questions were asked concerning acreages and widths of greenbelts to be acquired.

Discussion. - Early in the study the Bureau felt that the proposed plan would alter large areas of valuable fish and wildlife habitat and asked that sizable acreages be set aside as part of the proposed plan to mitigate those losses. The extent and type of areas affected and the aesthetic and environmental protection features associated with the proposed plan were not evident to the Bureau at that time. The District Engineer became personally involved in coordination with the Bureau, and in subsequent meetings effects of the plan were discussed and clarified, resulting in general agreement with the plan as proposed.

The proposed plan would require alteration of only about 40 acres of land entirely within the corporate limits of Chaska. Of this acreage, approximately 21.5 acres are cleared uplands zoned for residential, commercial, and industrial development; 2.5 acres are wooded uplands located in an industrial area of Chaska; 3 to 5 acres are low, wet meadow located in a residential area near the point of diversion of East Creek; and 12 acres are interspersed low woods and marsh mainly in the area of the proposed levee extension near Courthouse Lake.

Although the bypass channel would alter only 3 to 5 acres of wet meadow, the channel would skirt a marsh which was originally about 230 acres in area. The channel would complete drainage of 30 acres of partially drained lowland on the western fringe of the marsh. This area is zoned industrial or commercial and would likely be further developed with or without the proposed project. Precautions would be taken so that the marshland east of the bypass channel would not be adversely affected by the proposed project.

In addition to the eventual purchase of lands required by the project, the city of Chaska is acquiring mixed woodland and wetland areas along East and Chaska Creeks as part of a greenbelt and open-space acquisition program. The city has indicated that elimination of present land-use practices and preservation of the proposed greenbelt area would more than adequately compensate for fish and wildlife habitat losses directly and/or indirectly attributable to the proposed project. Environmental features of the plan of improvement include protecting the fishery of Courthouse Lake; preserving the proposed interior drainage ponding area in its natural state; and providing wildlife habitat by planting trees, shrubs, and grasses adjacent to the proposed levee and flood bypass channels. Additionally, about 525 acres of floodplain along the Minnesota River would be regulated and remain in its near-natural state.

In regard to the Bureau's questions concerning greenbelt acquisition, the city is purchasing about 500 acres of land for open space and park use. This will complement the open space policies of the Jonathan Development Corporation, which is committed to keeping 30 percent of its land as open space and under natural conditions in the northern part of the community. Of the 500 acres which the city is purchasing, about 100 acres will be acquired in the immediate project area which will add to the 40 acres of existing parkland and open space. The exact widths of greenways along Chaska Creek, Chaska Creek diversion, or East Creek are not completely defined, as purchasing of these areas is not complete. However, the city intends to have a continuous corridor along Chaska Creek diversion and a similar corridor along East Creek which will connect the greenbelts of upper East Creek to Courthouse Lake Park. These plans are illustrated in this report on plate C-2, Chaska Land Use, Future Conditions. Coordination with the Bureau on fish and wildlife matters will continue throughout postauthorization studies.

d. Department of Housing and Urban Development. -

Comment. - The Department of Housing and Urban Development had no adverse comments on the report but emphasized that the relocation of 13 residences should be arranged prior to implementation of the plan to assure compliance with policy and availability of benefits.

Discussion. - All relocations would be made in compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

e. U.S. Environmental Protection Agency. -

Comment. - The proposed construction of the East Creek flood bypass would have adverse effects on portions of 200 (corrected to 230) acres of wetland. Industrial zoning and the possible use of this area for the State Highway 41 interchange should not be used as pretexts for use of the wetlands for the diversion channel inasmuch as they represent possible alternative uses of the site. Using the sigma W method of discharge determination could result in underestimated discharges in the watersheds as they become urbanized. The future use of that portion of Chaska Creek which would be bypassed by the diversion channel should be explained. Plates C-1 and C-2 were not included in the draft survey report. Appendix F gives an excellent narrative of the ecosystems of Chaska and East Creeks as they may have been. A revision of the woodland descriptions in table F-1 to relate conditions past and present would be useful. The effects of temporary ponding on the water quality of Courthouse Lake should be discussed.

Discussion. - The East Creek flood bypass channel would displace about 4 acres of wetland. This wetland consists of low meadow grading to shallow, brushy marsh, located in a residentially zoned area of Chaska. Nearly the entire 4-acre area has already been drained by local interests. An impervious barrier along the bypass channel would prevent the channel from draining the remaining 226 acres of wetland. Recognition of anticipated land uses; land-use zoning; and the future plans of other Federal, State, county, and local interests in the study area is considered essential in the overall planning process including selection of the best alignment for the East Creek flood bypass. Future growth has been fully considered and recognized in the determination of discharges in our analysis. A discussion of the discharge-frequency curves for future developed conditions of East and Chaska Creeks is given in paragraphs 22 and 24 through 28 in appendix B of the survey report. The proposed use of the bypass portion of Chaska Creek has been included in the report. The colored plates C-1 and C-2 were not included in the draft report because of high cost. These plates are included in this report. U.S. Geological Survey maps were used to compute areas of woodland and marshland in the watersheds of the two creeks. No known maps are available which show wooded areas which

existed in the watershed prior to man's arrival to the area. Impacts on Courthouse Lake for conditions with and without the proposed improvements are discussed in appendix F under "Impacts Upon Surface Waters and Aquatic Biological Systems." The net impact on the lake would be slightly beneficial to local recreation, lake fishery, and water quality.

f. U.S. Bureau of Outdoor Recreation. -

Comment. - The Bureau of Outdoor Recreation stated that the proposed plan would enhance the recreational and environmental resources of the city of Chaska. The recreation features proposed are consistent with the Minnesota State Comprehensive Outdoor Recreation Plan. Of the alternatives considered, construction of four headwaters reservoirs in the East and Chaska Creek watersheds would appear to offer the greatest recreational opportunity.

Discussion. - The four headwaters reservoirs considered would maintain only a shallow sedimentation reserve pool which would not be very suitable for water-based recreational activities.

g. Minnesota Department of Highways. -

Comment. - The Minnesota Department of Highways requested that final designs for the Chaska Creek diversion channel in the vicinity of the crossing of Highway 212, the East Creek flood bypass channel from station 25+00 to 50+00, and the proposed bridge on Highway 41 be submitted for review and approval. A more westerly alignment for the proposed East Creek flood bypass channel would be desirable from the viewpoint of highway design at the proposed Highway 212. The Department of Highways should be advised of the proposed construction schedule.

Discussion. Coordination will be maintained during post-authorization studies and continued into the construction phase.

h. Minnesota Pollution Control Agency. -

Comment. - The proposed plan should be coordinated with the Minnesota Department of Natural Resources and the U.S. Geological Survey floodplain study for the lower Minnesota River. The sentence which states that plan 8 is the most acceptable was noted, and the meaning of acceptable limits was questioned. Problems that may be encountered by crossing watershed boundaries with the diversion and bypass channels were not mentioned in the report. Recommendation was made to sample creek bottoms in the developed areas. The disposition of spoil materials from the channel excavations was questioned.

Discussion. - Pertinent information from the U.S. Geological Survey floodplain study for the lower Minnesota River was utilized. No opposition to the plan has been voiced by either the Minnesota Department of Natural Resources or the U.S. Geological Survey. The sentence relative to acceptable limits has been clarified in the final report. The proposed East Creek flood bypass channel alignment closely approximates a historic alignment of East Creek. The Chaska Creek diversion would be within its present watershed boundary. Accordingly, no problems with watershed boundaries are anticipated. Detailed borings and soils analysis will be accomplished during postauthorization studies. Suitable spoil materials from channel excavation would be used for levee fill and overburden for general landscaping and architectural treatments. Unsuitable spoil material would be deposited in an environmentally acceptable area selected during postauthorization studies and provided by the city of Chaska.

i. Minnesota Department of Natural Resources. -

Comment. - The Department stated that all possible practical alternatives to flood damage reduction appear to have been evaluated, and that the recommended plan is the best comprehensive plan for flood damage reduction. The future use of the Chaska Creek channel should be explained. The Division of Game and Fish approved the plan and indicated no adverse effects to fish or wildlife resources would occur with the proposed project. The Division of Parks and Recreation stressed that all development be planned to blend into the existing landscape and recommended that lands for improvements be maintained in public ownership. The concept of a recreation trail system as included in the proposed plan was favored. A report on significant historic sites in the area was recommended.

Discussion. - The proposed use of the portion of Chaska Creek which would be bypassed by the channel diversion has been discussed in the report. Channels would be designed to blend into the natural topography to the maximum possible extent and a gently curving channel alignment would be used where practicable. Overbuilt areas and plantings on the proposed levee would be used to beautify the structure. As part of the requirements of local cooperation, local interests must provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction of the project. These lands would be in public ownership and the project would be operated and maintained in accordance with regulations prescribed by the Secretary of the Army. Paragraph 70 in appendix F explains proposed project impacts on historical and archeological sites. Additional investigation into the location of historic sites in the area would be made during postauthorization studies.

j. University of Minnesota, Department of Anthropology. -

Comment. - The Department of Anthropology stated that potential archeological areas noted from maps in the report and impact statements were examined. No surface evidence of any archeological remains was found.

k. Chicago, Milwaukee, St. Paul and Pacific Railroad Company. -

Comment. - The Chicago, Milwaukee, St. Paul and Pacific Railroad Company has no objection to the preliminary plan of improvement. The railroad wishes to review and approve the plans for the new railroad bridge over Chaska Creek prior to any construction, if the plan of improvement is approved and funded.

Discussion. - Coordination will be maintained during postauthorization planning and the final designs for the bridge will be submitted to the railroad for review and comment.

l. Metropolitan Sewer Board. -

Comment. - The Board is currently planning to expand the treatment facilities at the Chaska sewage treatment plant. Construction could begin in 1974 if a Federal grant is obtained. To better facilitate this expansion, the Board desires that any improvements made to the levee protecting the plant be done in such a manner as not to limit space inside this levee. The Board also reserves the right to have the proposed levee shifted to the southeast of the plant should future design evaluations show a need for additional space. The present outfall may be changed in conjunction with the expansion requiring coordination between the Board and the Corps.

Discussion. - Close coordination with the Board will be maintained throughout postauthorization studies on all matters pertinent to the Board.

m. County of Carver. -

Comment. - The County approved plan 8 and the alignment selected in plan 8 for the levee extension around Courthouse Lake. Stoughton Avenue is inventoried in the report as a Chaska city street and not a county-State aid highway as it should be. Construction of the proposed bridge on this road would be a county obligation. Plans for the levee trail system should be reviewed by the Carver County Board of Commissioners before initiation of project construction. The Board of Commissioners also wishes to make further comments regarding relocation of transportation corridors upon completion of the Carver County Transportation study now being prepared. By resolution the Board of County Commissioners has approved the proposed plan.

Discussion. - References to the proposed bridge on Stoughton Avenue have been corrected in the report. Close coordination with Carver County will be maintained throughout postauthorization studies.

n. City of Chaska. -

Comment. - By resolution, the city council has indicated its approval of the proposed plan and the city's intent to act as local sponsor of the project.

Comment. - The city of Chaska replied to the 1 June 1973 letter of the Bureau of Sport Fisheries and Wildlife, which was read into the record of the 7 June 1973 late stage public meeting at Chaska. The city indicated it would be unwilling and unable to provide 2,400 acres of mixed bottomland as a mitigation feature for fish and wildlife habitat losses on the 40 acres of land directly affected by the proposed levee and flood bypass channels. Much of the land upstream from the diversion project is owned by the Jonathan Development Corporation which is committed to plans approved by the Department of Housing and Urban Development. The Department requires that approximately 30 percent of the land remain in open space. This, together with the 500 acres of open space and parkland to be purchased by the city with Federal and State aid, is considered reasonable and adequate. In addition, the Minnesota Department of Natural Resources has no objection to the proposed project from an environmental standpoint. Thus, the city feels that the Bureau's requirement of 2,400 acres for fish and wildlife mitigation is unrealistic and unfounded.

Comment. - By resolution, the city council reaffirmed its intent to act as local sponsor of the project and recognized that any control structures, bridge, or other device at the intersection of East Creek and Highway 41 would be considered a local responsibility.

Discussion. - Our analysis of the direct losses of fish and wildlife habitat from construction of the proposed project indicates these losses would be adequately offset by the planned environmental protection features. These features include protecting the trout fishery of Courthouse Lake; preserving the proposed interior drainage ponding in its natural state; and providing wildlife habitat by planting trees, shrubs, and grasses adjacent to the proposed levee and flood bypass channels. Measures taken by the city to regulate the floodpoain, thus preserving it in its undeveloped state, and the open space and parkland policies described in the letter will insure availability of wildlife areas.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
316 North Robert Street, St. Paul, Minnesota 55101

May 25, 1973

Colonel Rodney E. Cox, District Engineer
St. Paul District, Corps of Engineers
1210 U. S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

Re: NCSED-PB River Basin - Review of Report Draft of Chaska, Minnesota Flood Prevention Surveys

We have reviewed the report draft and have the following comments. We wish to reiterate three of the comments we made in our letter of February 1, 1973, from Terpstra (SCS) to Northrup (C of E).

1. Soil Survey Maps, scale 1:15,840 are available at the SCS Field Office in Waconia, Minnesota (this should be added to paragraph 20).

2. The Carver County Soil and Water Conservation District has been active in working with farmers to devolop a good land treatment program. The District expects to work closely reviewing site plans for urban uses in the future, in the concerned watersheds. (Addition after paragraph 47).

3. Sediment producing banks are evident on the meandering creeks of the watershed. Erosion and sediment need to be controlled on new construction sites (this should be added to paragraph 57).

We appreciate the opportunity to review the report draft. Our comments on the draft of the Environmental Impact Statement will be forwarded to you by June 15, 1973. If you need further clarification on any item mentioned feel free to contact us.

Sincerely,

Harry M. Major
State Conservationist

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION 5
Suite 490, Metro Square Building
St. Paul, Minnesota 55101

May 31, 1973

IN REPLY REFER TO:

Colonel Rodney E. Cox
District Engineer
Corps of Engineers
St. Paul District
1210 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Re: Interim Study Report - Flood Control
Chaska, Minnesota

Dear Colonel Cox:

The Interim Survey Report, Minnesota River at Chaska, Minnesota for Flood Control has been reviewed as requested.

The study has been very extensively developed and is comprehensive in all areas which would be affected by the proposed flood control.

We note that the project does not require relocation of highways but structure modification and new structures over by-pass and diversion channels would be necessary. Costs involved are not eligible for Federal-aid highway funds under conditions stated in paragraph 85. It may be noted in this connection that the reference to U. S. Bureau of Public Roads should be changed to Federal Highway Administration.

It would appear that some minor numerical corrections might be desirable on page 29, Table 8, to change the standard project flood for Chaska Creek discharge from 9,000 cfs to 16,500 cfs and on B-17, paragraph 42, from 14,700 cfs to 4,700 cfs for the intermediate regional flood.

We appreciate the opportunity to review this study report which has accumulated a wealth of information for the proposed project and will be invaluable for future reference.

Very truly yours,

John S Bowers

John S. Bowers
Engineering Coordinator
For W. W. Fryhofer
Division Engineer

United States Department of the Interior

FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

IN REPLY REFER TO:
ES

October 31, 1973

Col. Rodney E. Cox
District Engineer
U. S. Army Engineer District
St. Paul
1210 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Col. Cox:

This letter responds to your request of October 19, 1973, concerning effects on fish and wildlife of the proposed flood control project at Chaska, Minnesota.

The Bureau of Sport Fisheries and Wildlife does not oppose the general concept of the project. We support the acquisition of the greenbelts and required Minnesota River floodplain regulations shown in green on the project maps. However, the following project specifics need to be developed or answered:

1. The exact acreage of greenbelt and parkland to be acquired by the city of Chaska.

2. The width of the greenbelt along either side of Chaska and East Creeks.

3. The width of easement devoted to greenbelt and wildlife travel lanes on either side of the Chaska Creek diversion.

Do not hesitate to contact us for any assistance needed regarding development of greenbelts and related wildlife mitigation aspects of the project.

Sincerely,

Jack E Hemphill

Jack E. Hemphill
Regional Director

cc: Director, Minnesota Department
of Natural Resources, St. Paul

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
300 SOUTH WACKER DRIVE, CHICAGO, ILLINOIS 60606

June 4, 1973

REGION V

IN REPLY REFER TO:
5M

Colonel Rodney E. Cox
District Engineer
St. Paul District, Corps of Engineers
Department of the Army
1210 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

This responds to your recent letter transmitting your report draft on the Minnesota River at Chaska, Minnesota.

We have no adverse comments with respect to the report. We wish to emphasize, however, that the relocation of 13 residences be thoroughly provided for in terms of policy and the availability of benefits prior to the implementation of the plan.

Sincerely,

Dean Swartzel
Assistant Regional Administrator
for Community Planning & Management

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
1 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

JUN 15 1973

Colonel Rodney Cox
District Engineer
U.S. Army, Corps of Engineers
1210 U.S. Post Office and Customs House
St. Paul, Minnesota 55101

Dear Colonel Cox:

Our review of the Interim Survey Report - Minnesota River at Chaska, Minnesota has been completed and the following comments are forwarded for your information.

1. The wetlands policy of EPA is quite explicit in stating that wetland areas are of major ecological value and consequently require extraordinary protection from development. The construction of the East Creek diversion channel will have a deleterious effect on portions of a 200 acre wetland area and modification of project measures to minimize the degradation of the quality of this wetland should be seriously considered. The present industrial zoning of the wetland area and the possible use of the area for the State Highway 41 interchange should not be pretexts for the use of the wetlands for the diversion channel inasmuch as they represent possible alternative uses of the site.

2. The problem of gathering valid hydrologic data from ungaged watersheds such as Chaska and East Creeks is recognized.

However, the Sigma W method of discharge determination uses soil conditions and vegetal cover as two of the four evaluation parameters. In these watersheds in which urban development is imminent this methodology could seriously underestimate discharges because these parameters are largely negated as the watershed becomes more impervious to water with development.

3. Part of the proposed project calls for a change of the channel of Chaska Creek from the present location in a residential-commercial area to a less developed area on the edge of the community. The survey report should state what ultimately is to become of the original channel. Is it to be filled? Will it remain to provide interior drainage? Will low flow be maintained?

JUN 15 1973

4. Plates C-1 and C-2 (Appendix C) depicting present and future land-use in the City of Chaska were missing from the review copy of the survey report.

5. The extensive narrative description of the ecosystems of Chaska and East Creeks (Appendix F) is an excellent portrayal of what pre-existing conditions may have been.

However it is difficult to relate this information to present conditions. A revision of the woodland descriptions in Table F-1 would be useful in accomplishing this.

6. There should be an expanded discussion of the effects of water from East Creek on the water quality of Courthouse Lake when high flow in the East Creek Channel requires the use of the temporary ponding area. The length of time that the temporary storage would be required should also be discussed.

Sincerely yours,

Francis T. Mayo

Francis T. Mayo
Regional Administrator

AD-A119 393 CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT F/G 13/2
FEASIBILITY REPORT FOR FLOOD CONTROL, MINNESOTA RIVER AT CHASKA--ETC(U)
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United States Department of the Interior

BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48104

IN REPLY REFER TO:
D6427 UM

June 15, 1973

District Engineer
U.S. Army Corps of Engineers
St. Paul
1210 USPO and Custom House
St. Paul, Minnesota 55101

Dear Sir:

We have reviewed the preliminary draft of the interim flood control survey at Chaska, Minnesota, as requested in your letter of May 15.

The project, as recommended, consists of 0.9 mile of diversion channel, 1.2 mile of flood bypass channel, 1.1 mile of upgraded levee, and 0.6 mile of new levee at an estimated Federal cost of $8,262,000 and a non-Federal cost of $1,281,000. The proposed plan includes about 1.6 miles of paved recreation trails on top of the levee and around Courthouse Lake. The proposed trails could be readily connected to the Minnesota River Valley Trail System which is being cost-shared by BOR with the State through the Land and Water Conservation Fund.

Of the several alternative measures considered in the report, the construction of four headwater reservoirs in the East Creek and Chaska Creek Watershed would appear to offer the greatest recreational opportunities. However, we understand that this was determined to be the most costly alternative and would intermittently inundate about 495 acres of wetlands and narrow fringes of wooded slopes. Also, the "Minnesota Outdoor Recreation Plan - 1968" does not consider additional outdoor recreation water surface to be a critical need in Minnesota.

The project, as proposed, will enhance the recreational and environmental resources of the village of Chaska and is considered to be consistent with the Minnesota State Comprehensive Outdoor Recreation Plan in that the need for walking and bicycling trails is extremely high in this portion of the state.

We are not providing comments to the draft environmental impact statement at this time, but our comments will be incorporated in a Departmental response which will be submitted to you later.

Sincerely yours,

JOHN D. CHERRY
Regional Director

By: Robert H. Myers
Robert H. Myers
Acting

STATE OF MINNESOTA
DEPARTMENT OF HIGHWAYS
ST. PAUL, MINN. 55155

June 1, 1973

Colonel Rodney E. Cox
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1210 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

In reply refer to: 330
NCSED-PB
S.P. 1008 (T.H. 41)
S.P. 1013 (T.H. 212)
"Interim Survey Report
Minnesota River at Chaska
For Flood Control"
Review and Comment

Dear Colonel Cox:

As requested in your letter of May 15, 1973, we have reviewed the above referenced flood control survey report.

We have no objections to the implementation of Plan 8 as proposed in the report. The following comments regarding the effect of Plan 8 on T.H. 41 and T.H. 212 are offered for your consideration:

1. Final design plans, prepared by the Corps of Engineers, for the proposed flood control construction at the following locations, should be submitted to the Highway Department for review and approval:

    a. The Chaska Creek diversion channel in the vicinity of channel sta. 43 (existing T.H. 212 crossing).

    b. The East Creek diversion channel in the vicinity of channel sta. 25 to 50. The bridge railing and approach guard rail required on the bridge where the proposed channel crosses under existing T.H. 212 will create a horizontal sight distance restriction at the interchange with existing T.H. 212 and proposed T.H. 41. It would be desirable to shift the channel crossing westerly as far as possible to minimize this problem. In addition

a minor realignment of existing T.H. 212 is contemplated at this location, therefore details regarding the location and construction time schedule for this structure will require close coordination.

c. The replacement of the existing T.H. 41 box culvert on East Creek with a bridge.

2. The Highway Department should be advised of the proposed construction schedule as soon as practicable.

We would appreciate being kept informed of progress regarding further development of this flood control project.

Sincerely,

W J Ekern

by Ray Lappegaard
Commissioner

MINNESOTA POLLUTION CONTROL AGENCY
717 Delaware Street S.E. / Minneapolis, Minnesota 55440
(612) 296-5500

June 19, 1973

Colonel Rodney E. Cox, District Engineer
St. Paul District, Corp of Engineers
1210 U. S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

We find your draft "Interim Survey Report, Minnesota River at Chaska, Minnesota, for Flood Control" generally good. We do have several comments.

1. Page 15, #37
   What is the cooperation between this project and the DNR and USGS floodplain study for the Lower Minnesota?

2. Page 28, #63
   "Thus, plan 8, . . ., is the most acceptable alternative since environmental changes would be within acceptable limits, . . ."
   What are "Acceptable limits?"

3. Page 30, #69
   There is no mention made of the problems of bypassing East Creek and Chaska Creek over watershed boundaries.

4. We also recommend that sample data be obtained from creek bottoms, particularly those sections where there is development.

5. What will be the disposition of spoil material?

Please feel free to contact us on any question you may have on our comments.

Sincerely,

Grant J. Merritt
Executive Director

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
CENTENNIAL OFFICE BUILDING • ST. PAUL, MINNESOTA • 55155

June 21, 1973

Colonel Rodney E. Cox
St. Paul District, Corps of Engineers
1210 U. S. Post Office
St. Paul, Minnesota

Dear Colonel Cox:

We have reviewed the draft of the "Interim Survey Report for Flood Control at Chaska, Minnesota", dated April 1973, prepared by the St. Paul District, U. S. Army Corps of Engineers.

It appears that the Corps of Engineers has considered all practical alternatives for reduction of flood damages at Chaska. The recommended plan, which consists of diverting flood flows of Chaska Creek and East Creek, upgrading and extending the existing emergency levee along the Minnesota River, continued flood plain regulation along the Minnesota River and adoption of flood plain regulations along East Creek and Chaska Creek until the proposed flood control measures are in place, and regulation of the residual flood plain afterwards, offers the best means for achieving this flood damage reduction objective.

The Division of Game and Fish has expressed their approval of this project and indicated that the project will not have an adverse effect on fish or wildlife resources.

The Division of Parks and Recreation, has submitted the following comments on the interim survey report draft:

All development, whether dikes or new channels, should be developed with natural slopes, irregular lines and as near natural conditions as possible should be retained. This would mean that there would be no straight grades, constant slopes, concrete flumes, etc. In this matter, we would be happy to go over detailed plans and make specific recommendations.

The concept of maintaining a trail system should be reinforced because this will be important to the community as well as the region and the state. We recommend that the creek diversion be held in public ownership so that any repair work, rip-rapping, etc., would not require any additional permits to enter onto private property. This corridor for the new diversion channels also could be used as a corridor for the proposed local trails.

We see no mention of historic significance in this report. We recommend that special care be made in preserving some of the old historic points of interest as well as the old historic stage coach trail going through this area. We recommend that a report be made on this point.

The only other suggestion that I would make is that explicit reference to the future use of the existing Chaska Creek channel be clearly documented in the final draft.

Sincerely,

Eugene R. Gere

Eugene R. Gere, Director
Division of Waters, Soils & Minerals

ERG:KSE:bh

UNIVERSITY OF MINNESOTA
TWIN CITIES

Department of Anthropology
215 Ford Hall
Minneapolis, Minnesota 55455

June 4, 1973

Colonel Rodney E. Cox
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1210 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

Thank you for copies of the preliminary reports on the proposed flood control project at Chaska, Minnesota. We have examined potential archaeological areas noted from the maps included in those reports and find no surface evidence of any archaeological remains.

I should comment that the environmental impact statement is certainly very well done but we would appreciate it if you would consult professional archaeologists in the preparation of any future impact studies. I noted that ecological, the water resources, hydrological and other impact statements were all prepared by professionals in those fields for the Chaska report but the historic site and archaeological statement was based on information supplied by local residents. It seems to me that archaeological value should receive as much attention as other resources and environmental factors.

Sincerely yours,

Elden Johnson
Elden Johnson
State Archaeologist

EJ:nh

cc: Russell Fridley

Chicago, Milwaukee, St. Paul and Pacific Railroad Company
898 UNION STATION—CHICAGO, ILLINOIS 60606

B. J. WORLEY
VICE PRESIDENT-CHIEF ENGINEER

June 11, 1973
0-114
M-41637.2

Colonel Rodney E. Cox
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1210 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

Please refer to your letter of May 15, file: NCSED-PB, furnishing us a copy of draft of Interim Survey Report, Minnesota River at Chaska, Minnesota, for flood control, marked "Preliminary To Be Revised".

It is noted that recommendation has been made for a plan which, among other things, involves the diversion of Chaska Creek as shown on Plate No. 5, in the report.

This part of the recommended preliminary project will involve the construction of a new railroad bridge to replace our existing 5-span pile trestle bridge 0-114 over Chaska Creek west of Cedar Street at Chaska with all costs and expenses for the new bridge to be assumed by the Federal Government.

In general, we have no objection to the preliminary plan of improvement. This, however, is with the understanding that when and if the plan of improvement is approved and funded by the Government, we will be given the opportunity to review and approve the plans for new bridge construction under our track prior to commencing of any work.

Yours very truly,

B Jworley

cc - Mr. N. E. Smith
Mr. W. C. Whitham

850 Metro Square Bldg., 7th & Robert, St. Paul, Minn. 55101 Area 612, 222-

June 13, 1973

Mr. Rodney E. Cox
Colonel, Corps of Engineers
District Engineer
U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Subject: Chaska Flood Control Improvements, NCSED-PB

Dear Mr. Cox:

We have reviewed the draft of the Interim Survey Report for Flood Control, Minnesota River at Chaska, Minnesota and submit the following comments relating to our planning and to the levee improvements in the vicinity of the Chaska wastewater treatment plant.

The Sewer Board is currently planning an expansion to the treatment facilities at the existing plant site. This expansion will utilize all available space within the present dike protected enclosure. Any improvements requiring widening of the existing levee or flatening the inside levee slope should be accomplished by filling on the outside face.

Our planning for the present and future plant improvements is in the preliminary engineering phase. The extent and the timing ofthe plant improvements is somewhat uncertain at this time. We anticipate that construction for the present expansion could commence in 1974 provided a Federal grant is obtained. Preliminary planning provides for the plant to be phased out when the expanded plant reaches capacity during the period from 1985 to 1990. The wastewater flows will be diverted to a regional wastewater treatment at the Blue Lake plant on the Minnesota River between Shakopee and Savage.

The expansion of the plant at Chaska is limited by the available space. Our Engineering Feasibility Study has considered the alternate of constructing a permanent plant at another site which could then be expanded as needed. The preliminary proposed site would be north of the present plant near the terminal point of the levee and located

on high ground north of East Creek; however, at this point in time we consider this alternate as the least desirable of the several alternates studied.

The expansion of the present plant may be staged over a period of approximately five years. We, therefore, desire to keep the option open to have the proposed levee shifted southeast of the plant site if future design evaluations indicate the need for additional space.

The present outfall through the levee may be changed in conjunction with the design of permanent flood pumping facilities for the plant effluent. We will coordinate this anticipated improvement with your office.

The Metropolitan Sewer Board is an operating agency within the Metropolitan Council which is the designated planning agency for the Metropolitan Area. It has come to our attention that the Metropolitan Council apparently has not been requested to comment on the subject report. You should contact them in this regard.

Sincerely,

METROPOLITAN SEWER BOARD

L. E. Dye

Lonnie E. Dye
Chief Engineer

LED:KEF:CRP:sil

CC: McCombs-Knutson Associates, Inc.
Frank Lamm, Environmental Engineer, Metropolitan Council

COUNTY OF CARVER

CHASKA, MINNESOTA 55318

OFFICE OF
DIRECTOR OF PUBLIC WORKS
PATRICK B. MURPHY
Phone 448-3435 Ext. 29

June 26, 1973

Mr. Carl E. Borash
St. Paul District Corps of Engineers
1210 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Borash:

Upon reviewal of the Corp of Engineers Interim Survey Report and Environmental Impact Statement for Flood Control on the Minnesota River at Chaska, I have made the following observations:

1. Preservation of the Courthouse Lake and surrounding recreational park area is definitely a positive approach to the environmental considerations of the area. Removal of the emergency levee near the courthouse will greatly enhance the attractiveness of the courthouse facility.

2. Stoughton Avenue is mistakenly inventoried as a Chaska City Street. Stoughton Ave. is a County State Aid Highway (CSAH #10) and construction of a bridge on this road facility would be a county obligation.

3. The construction of a levee trail system around Courthouse Lake should be subject to review by the Carver County Board of Commissioners before initiation of the project.

4. Carver County reserves the right to make further comments regarding relocation of transportation corridors upon completion of the Carver County Transportation Study now being prepared.

5. Plan 8 provides the necessary safeguards to minimize dangerous flooding. Continuing study and eventual construction of the mentioned facilities will be beneficial in many aspects. Please do not hesitate

COUNTY OF CARVER

CHASKA, MINNESOTA 55318

OFFICE OF
DIRECTOR OF PUBLIC WORKS
PATRICK B. MURPHY
Phone 448-3435 Ext. 29

to contact our office during the period of post-authorization study if you feel we can be of assistance.

I appreciate the time and attention you have given this letter.

Sincerely,

Donald Wisniewski

Donald Wisniewski
Asst. County Engineer

DW:ss

COUNTY OF CARVER

CHASKA, MINNESOTA 55318

OFFICE OF
DIRECTOR OF PUBLIC WORKS
PATRICK B. MURPHY
Phone [illegible] Ext. 29

June 26, 1973

Rodney E. Cox
Colonel, Corps of Engineers
District Engineer
St. Paul District Corps of Engineers
1210 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Cox:

Enclosed herewith is a resolution from the Carver County Board of Commissioners recommending that the Corp of Engineers Plan 8 for the Minnesota River Flood Control Project at Chaska, Minnesota be adopted and implemented. Carver County recognizes that these proposed improvements will indeed help to minimize loss of life and property during flooding periods.

Please include this resolution with the formal statements received as a result of the public hearing of June 7, 1973.

I appreciate the time and attention you have given this letter.

Sincerely,

Patrick B. Murphy

Patrick B. Murphy
Director of Public Works
Carver County, Minnesota

PBM:ss

Enclosure

BOARD OF COUNTY COMMISSIONERS

CARVER COUNTY, MINNESOTA

Date June 26, 1973 Resolution No. 29-73

Motion by Commissioner Gnan Seconded by Commissioner Holtmeier

BE IT RESOLVED, That the Carver County Board of Commissioners recommend adoption and implementation of the Corps of Engineer Flood Control project for the Minnesota River at Chaska.

BE IT FURTHER RESOLVED, That the Corps of Engineers continue to study and promote Plan 8 as discussed in the interim survey report and at the public hearing on June 7, 1973. On vote taken, all voted aye.

YES	ABSENT	NO
Gnan	Anderson	
Holtmeier		
Weston		
Schneider		

State of Minnesota
County of Carver } ss.

I, William J. Schneider, duly elected, qualified and acting County Auditor for the County of Carver, State of Minnesota, do hereby certify that I have compared the foregoing copy of a resolution with the original minutes of the proceedings of the Board of County Commissioners, Carver County, Minnesota, at their session held on the 26th. day of June 19 73, now on file in my office, and have found the same to be a true and correct copy thereof.

Witness my hand and official seal at Chaska, Minnesota, this 29th. day of June, 1973

County Auditor
William J. Schneider

Mr. Rodney E. Cox
Page 2
October 12, 1972

I am pleased to hear that you are actively seeking the involvement of local interests in developing this program, particularly that of the Northwestern Wisconsin Regional Planning and Development Commission, and encourage you to continue to work with that agency on problems of areawide concern in Northwestern Wisconsin.

Sincerely,

PATRICK J. LUCEY
Governor

PJL:pls

cc: Miles Beckstrom, Mayor of Montreal
Willis W. Capps, State Director, Farmers Home Administration
John Geshel, Village Chairman of Pence
Ernest Korpela, State Representative of Ashland, Bayfield and Iron Counties
Fred Lanta, Village Chairman of Iron Belt
Leland Newman, Executive Director, Northwestern Wisconsin Regional Planning and Development Commission
Hanford Olson, State Representative, Economic Development Administration
Paul Santini, Mayor of Hurley
Jeffrey Smoller, Staff Director, Upper Great Lakes Regional Commission
Lester P. Voigt, Secretary, Department of Natural Resources

CITY OF CHASKA
CARVER COUNTY, MINNESOTA

RESOLUTION

Date: June 12, 1973 Resolution No. 73-41

Motion by Siewert Seconded by Councilman Rehling

WHEREAS, the residents of the City of Chaska, Carver County, Minnesota, have suffered severe damage and loss of property during past floods on the Minnesota River, Chaska Creek and East Creek; and

WHEREAS, the Corps of Engineers, U.S. Army, has been authorized by the House of Representatives of the United States Congress to determine whether improvements for flood control are advisable in the Chaska area; and

WHEREAS, the District Engineer, St. Paul District, Corps of Engineers, U.S. Army, has examined the vicinity of flood damage and has prepared a survey report which indicates that economic feasibility exists for flood protection measures; and

WHEREAS, improvements for flood protection can be undertaken subject to authorization and appropriation of funds by Congress, provided that responsible local interests agree that when requested they will give assurances satisfactory to the Secretary of the Army that they will:

a. Provide, without cost to the United States, all lands, [illegible]

c. [illegible] ment and where the appraised value of these lands furnished amounts to less than 50 percent of the total first cost of recreation development, sufficient addi-

tional contributions shall be provided to bring the non-Federal share to at least 50 percent of the total first cost of recreation development.

c. Hold and save the United States free from damages due to the construction works.

d. Maintain and operate the recreation facilities and the project after completion in accordance with regulations prescribed by the Secretary of the Army.

e. Prevent any encroachment on the existing East Creek and Chaska Creek channels, constructed works, floodways, and ponding areas that would interfere with the proper functioning of the project and, if ponding is impaired, provide promptly and without cost to the United States substitute storage or equivalent pumping capacity.

f. Provide without cost to the United States all relocations of buildings and utilities, highway bridges, roads, and sewers, except as otherwise warranted for special reasons.

g. Implement and administer floodplain regulations in accordance with State law where intermediate regional flood protection is not provided.

WHEREAS, the City of Chaska, Carver County, Minnesota, recognizes that construction of flood protection works is essential to the residents of this City for their public health and general welfare;

NOW, THEREFORE, BE IT RESOLVED by the City Council, City of Chaska, Minnesota:

1. That the City intends to approach the state Legislature to obtain the legal capacity to act as local sponsor and to furnish the required local cooperation if and when requested;

2. That the City desires flood protection for its residents and hereby declares its willingness and intention to gain the legal capacity and to undertake and carry out the items of local cooperation substantially as set forth above, as and when requested.

3. That certified copies of this resolution be furnished to and filed with the District Engineer at St. Paul, Minnesota, as evidence of the City's approval of a project for flood control in said City of Chaska, Carver County, Minnesota, and of its intent and willingness to cooperate with the United States as specified.

Passed and adopted by the City Council of the City of Chaska, Minnesota, this 12th day of June, 1973.

Edgar F. Ziegler Jr.
Edgar F. Ziegler, Mayor of
the City of Chaska, Minnesota

Attest: Shirley Bruers
Shirley Bruers, City Clerk
of the City of Chaska, Minn.

STATE OF MINNESOTA }
COUNTY OF CARVER } SS

I, Shirley Bruers, City Clerk of the City of Chaska, Minnesota, do hereby certify that I have compared the attached copy of a resolution with the original resolution on file in my office and that the foregoing is a true and correct copy of the said resolution and of the whole thereof.

Witness my hand this 13 day of June, 1973.

Shirley Bruers
City Clerk of Chaska, Minnesota

Chaska

July 16, 1973

Colonel Rodney E. Cox
District Engineer
U. S. Army Corp of Engineers
St. Paul District
1210 U. S. Post Office and Custom House
St. Paul, Minnesota 55101

Re: Proposed Chaska Creek Diversion Project.
Reply to Comments of U. S. Department of Interior
Bureau of Sport Fisheries and Wildlife

Dear Colonel Cox;

On behalf of the City of Chaska we wish to reply to the letter dated June 1, 1973 from Mr. Travis S. Roberts, Regional Director, of the United States Department of Interior, Bureau of Sports, Fisheries and Wildlife. Mr. Robert's letter claims that the proposed Creek Diversion Project in Chaska will adversely affect 2,400 acres of fish and wildlife habitat. Mr. Roberts therefore, recommends that the city should acquire a minimum of 2,400 acres of mixed bottom land to compensate for the so-called losses of fish and wildlife habitat directly attributable to the project.

We wish to go on record stating that the City of Chaska cannot and will not provide 2,400 acres of mixed bottom land for the following reasons. First, the acquisition of lands and right-of-way is a local financial responsibility. The City of Chaska cannot afford to acquire 2,400 acres of land in addition to what is now being acquired for open space and park purposes. Second, the proposed project directly affects no more than 40 acres of land for construction purposes as we understand it. We fail to see how this project involving 40 acres of land directly by providing two diversion channels in the southerly part of our community will adversely affect 2,400 acres of any kind of land. Third, we would like to point out that much of the land upstream from the diversion project is owned by the Jonathan Development Corporation which has a twenty year contract with the Department of Housing and Urban Development to develop a new town on this property. The Development Company is committed to plans approved by H. U. D. which will require approximately 30% of all of their land to remain in open space and natural conditions. The remaining 70% of their land will be developed over a twenty year period under the contract with H. U. D. Consequently the storm run-off in this area will continue to grow in magnitude, and areas would be drained

City Of Chaska Minnesota 205 East Fourth Street 55318 Phone 612-448-2851

because of the urban development of the land. The proposed project in no way encourages the development or drainage of this land. Rather it is a project to protect the southern part of the community from a rapid run-off due to development of the land which was planned long before this project was initiated.

Fourth, we would like to point out that the City of Chaska is purchasing 500 acres of land for open space and park use. Part of these 500 acres is to be along the proposed diversion projects. We are purchasing this property with the aid of a $560,000.00 grant from the Department of Housing and Urban Development and a $190,000.00 grant from the State of Minnesota. In addition the citizens of Chaska have approved a bond referendum in the amount of $260,000.00 to provide the local share of the park acquisition costs. We feel that with the acquisition of the city property in the south end and the committment of the Jonathan Development Corporation to keep 30% of it's land open and under natural conditions in the northern part of the community, that we are more than providing reasonable requirements for fish and wildlife habitat.

We would also like to point out that the Minnesota Department of Natural Resources has also reviewed the project and has no objections to the project from an environmental stand point.

Based on the above stated reasons we feel the requirement to purchase an additional 2,400 acres of mixed bottom land and the objections listed by Mr. Roberts in his letter are without foundation. We feel the objections and recommendations listed by the Bureau of Sport Fisheries and Wildlife are not applicable to our project.

Respectfully yours,

Edgar F. Ziegler D.D.S.

Edgar F. Ziegler, D. D. S.
Mayor

cc: Congressman Ancher Nelson

CITY OF CHASKA
CARVER COUNTY, MINNESOTA

RESOLUTION

Date: March 18, 1974 Resolution No. 74-6

Motion by Alderman Born Seconded by Councilman Alderman Siewert

WHEREAS, pursuant to Resolution 73-41, dated June 12, 1973, the City of Chaska did provide the necessary assurances to the Corps of Engineers, U.S. Army, regarding the local participation and responsibility relative to the Interim Survey Report, Minnesota River at Chaska, Minnesota, for Flood Contro; and

WHEREAS, the City of Chaska has now been informed, and has been made aware of, the fact that any control structure, bridge, or other device determined necessary on State Trunk Highway No. 41 at the intersection of said State Trunk Highway No. 41 and the Chaska East Creek will, of necessity, be of local responsibility;

NOW, THEREFORE, BE IT RESOLVED, by the City Council of the City of Chaska, Minnesota, as follows:

1. The City Council of the City of Chaska, Minnesota, does hereby recognize that any control structure, bridge, or other device deemed necessary by the Corps of Engineers, U.S. Army, to be constructed at the intersection of State Trunk Highway No. 41 and Chaska East Creek relative to the flood control project undertaken by the Corps of Engineers, U.S. Army, shall be considered an item of local responsibility.

2. The City Council of the City of Chaska, Minnesota, does hereby in all respects reaffirm Resolution No. 73-41, dated June 12, 1973.

Passed and adopted by the City Council of the City of Chaska, Minnesota, this 18th day of March 1974.

Edgar F. Ziegler A.A.V.

/s/ Edgar F. Ziegler
Mayor

Attest: /s/ Shirley Bruers
City Clerk

ATTACHMENT 1

MINNESOTA RIVER, CHASKA, MINNESOTA

Information Called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

1. PROPOSED PROJECT

The proposed project provides for construction of a flood bypass channel on East Creek, a diversion channel on Chaska Creek, upgrading and extension of the present Minnesota River levee, and installation of adequate interior drainage facilities. Principle project features include approximately 2 miles of riprapped channel, 0.1 mile of concrete-lined channel, 1.1 miles of upgraded levee, 0.6 mile of new levee, four pumping stations, interceptor sewers and ditches for interior drainage, and a sound program for controlling land use and development in remaining floodplain areas in accordance with State law. A recreation trail system and other aesthetic treatment measures are also included in the proposed plan. The project would be designed to provide protection against the estimated intermediate regional flood from East Creek, Chaska Creek and the Minnesota River. The project would have an estimated economic life of 100 years.

2. PROJECT COST

The estimated first costs of the proposed project, based on price levels prevailing in February 1973. are as follows:

Federal	$8,014,000
Non-Federal	1,529,000
Total	9,543,000

3. AVERAGE ANNUAL COSTS AND BENEFITS

Average annual costs for the proposed project have been computed for assumed economic lives of 50 years and 100 years and are based on an interest rate of 5 5/8 percent. Flood control tangible benefits attributable to the proposed project have been estimated for periods of 50 years and 100 years. A summary of the annual charges, benefits, and benefit-cost ratios follows:

	Economic life of project	
	50 years	100 years
Federal annual charges		
Capital costs	$505,000	$475,000
Maintenance, operation and major replacements	-	-
Total Federal annual charges	505,000	475,000
Non-Federal annual charges		
Capital costs	92,000	86,000
Maintenance, operation and major replacements	18,000	18,000
Total non-Federal annual charges	110,000	104,000
Total average annual charges	615,000	579,000
Total average annual benefits	742,000	771,000
Ratio of benefits to costs	1.2	1.3

4. ALTERNATIVE PROJECTS

All of the various means of reducing flood damages including both nonstructural and structural alternatives and combinations of these measures were systematically analyzed and compared for Chaska. Because of the existing vast developments that would have to be relocated in Chaska, permanent evacuation was found to be totally impracticable and socially unacceptable. Other nonstructural techniques including flood proofing, flood warning, flood insurance and floodplain regulation by themselves would not significantly reduce flood damages in the city. However, floodplain regulation in accordance with State law was considered further as a supplement to possible structural measures. Of the fourteen structural alternatives considered, which included combinations of reservoirs, levees, channel improvement, channel diversion, and flood bypass channels, three plans were identified as best meeting the flood control needs at Chaska. These are the proposed plan as described in paragraph 1; channel improvements on the two creeks in combination with upgrading and extending the existing levee system; and a plan incorporating a system of four upstream reservoirs in combination with the flood bypass channel, a channel diversion and the levee upgrading and extension. The proposed plan is preferred by the residents of Chaska and is the most economically favorable. Environmentally, the proposed plan ranked second only to the plan which includes the four upstream reservoirs. Thus, the proposed plan was selected as the best of the considered alternatives.

5. DISCUSSION

The study verifies the existence of a severe flood problem in Chaska where some 540 residences, 47 businesses and industries, three public buildings, the city water supply and sanitary system, streets, roads and public utilities are directly affected by flooding of the two creeks and the Minnesota River. Damages estimated at $4 million would result from the intermediate regional flood under present conditions. Of even greater significance, the investigation has shown that a substantial loss of life could occur at Chaska as a result of either failure of the existing emergency levee system or potential catastrophic consequences of an intense rainstorm in the East Creek watershed.

6. During the planning process an intensive investigation in cooperation with the city officials, Chaska Citizens Advisory Committee and State and Federal interests led to development of a floodplain management plan which incorporates both nonstructural and structural measures. Three basic objectives guided the study including national economic efficiency, environmental quality and social well-being. The recommended plan was found to best satisfy the three planning objectives and to meet the water and related land resources needs of Chaska.

DATE
ILMED
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